

Disassembly and Assembly

1103D Industrial Engine

XK (Engine)
XL (Engine)
XM (Engine)

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers or Perkins distributors have the most current information available.



When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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Disassembly and Assembly Section

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Fuel Priming Pump and Fuel Filter Base - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Put identification marks on all hoses, on all hose assemblies, on wires and on all tube assemblies for installation purposes. Plug all hose assemblies and tube assemblies. This helps to prevent fluid loss and this helps to keep contaminants from entering the system.

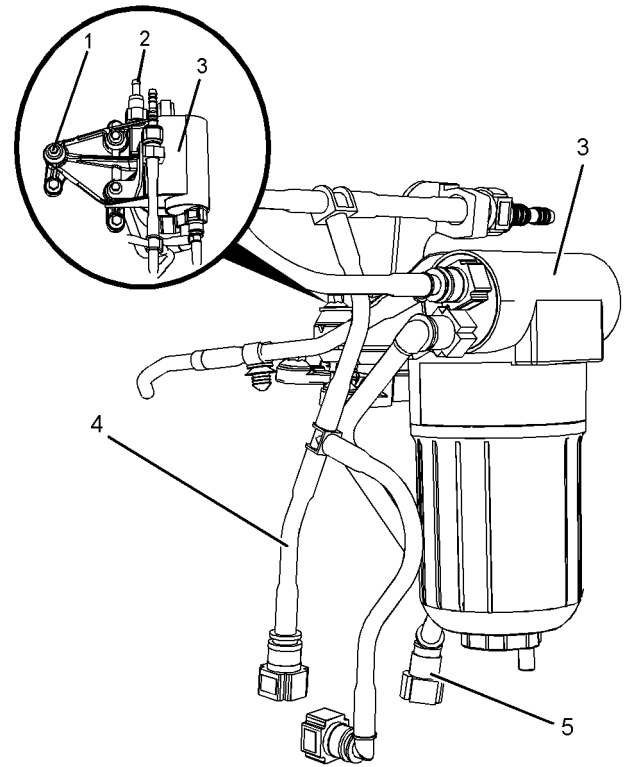


Illustration 1

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Typical example

1. Turn the fuel supply to the OFF position.
2. Turn the battery disconnect switch to the OFF position.
3. Disconnect plastic tube assembly (4) and plastic tube assembly (5) from fuel priming pump (3).
4. Disconnect plastic tube assembly (2) from fuel priming pump (3).
5. Plug all the connections on fuel priming pump (3) and plastic tube assembly (4) and plastic tube assembly (5).
6. Disconnect the harness assembly from fuel priming pump (3).
7. Support the fuel priming pump. Remove bolts and washers (1) and remove fuel priming pump (3).

Note: Note the location and the orientation of the brackets for the tube assembly.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

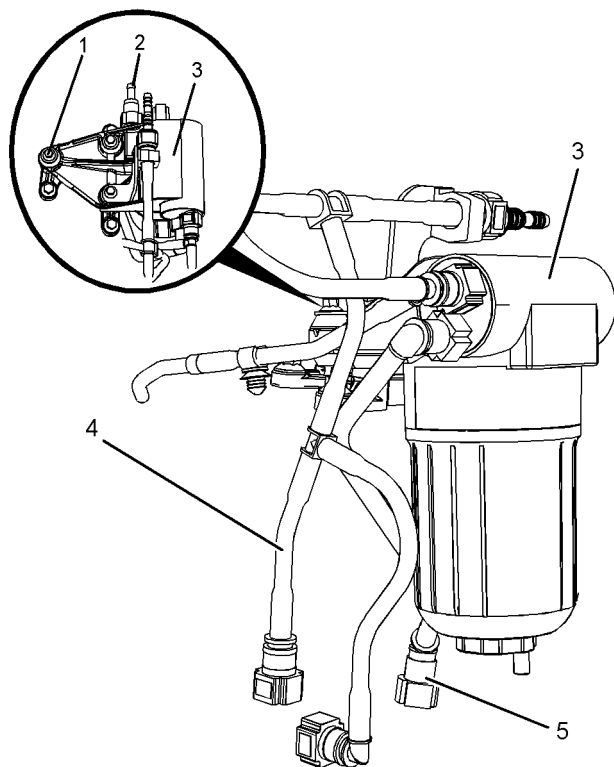


Illustration 2

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Typical example

1. Ensure that the fuel priming pump is clean and free from wear or damage. If necessary, replace the fuel priming pump as a complete assembly.
2. Position fuel priming pump (3) onto the cylinder head. Install bolts and washers (1). Ensure that any brackets that are retained by the bolts are installed in the correct position. Tighten the bolts to a torque on 9 N·m (80 lb in).
3. Remove all plugs from the fuel priming pump and from the plastic tube assemblies. Connect plastic tube assembly (4) and plastic tube assembly (5) to fuel priming pump (3).
4. Connect plastic tube assembly (2) to fuel priming pump (3).
5. Install the harness assembly to fuel priming pump (3).
6. Turn the fuel supply to the ON position.
7. Turn the battery disconnect switch to the ON position.
8. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, "Fuel System - Prime".

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Fuel Injection Lines - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

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NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Turn the fuel supply to the OFF position.
2. Turn the battery disconnect switch to the OFF position.
3. If the engine is equipped with a cover for the fuel injectors, remove the cover for the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
4. Remove the breather tube from the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the fuel injection lines for damage.
Replace any components that are damaged.

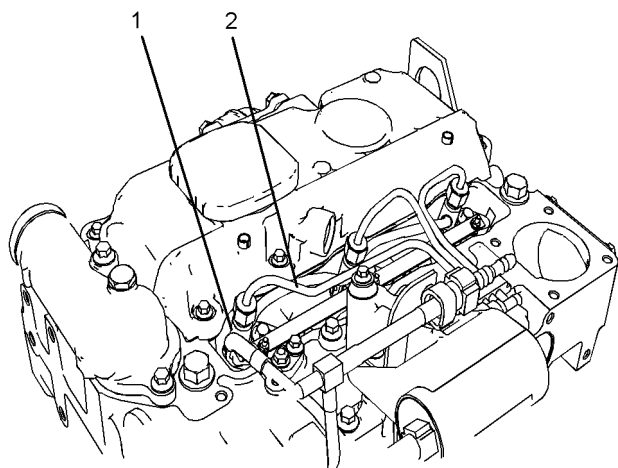


Illustration 3
Typical example

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5. Disconnect fuel injection lines (2) at fuel injectors (1).

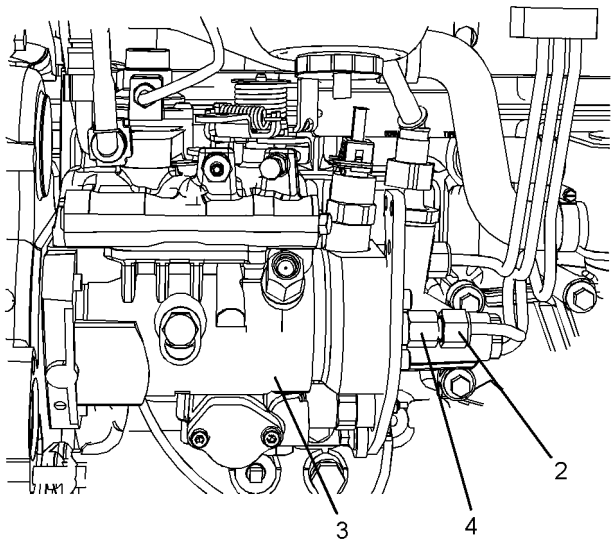


Illustration 4
Typical example

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6. Disconnect fuel injection lines (2) at fuel injection pump (3). Ensure that connections (4) do not turn.
7. Plug and cap all open ports, fuel injection lines and all tube assemblies.

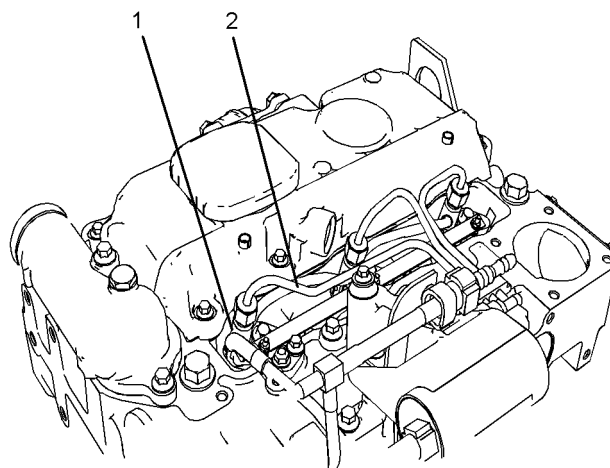


Illustration 5
Typical example

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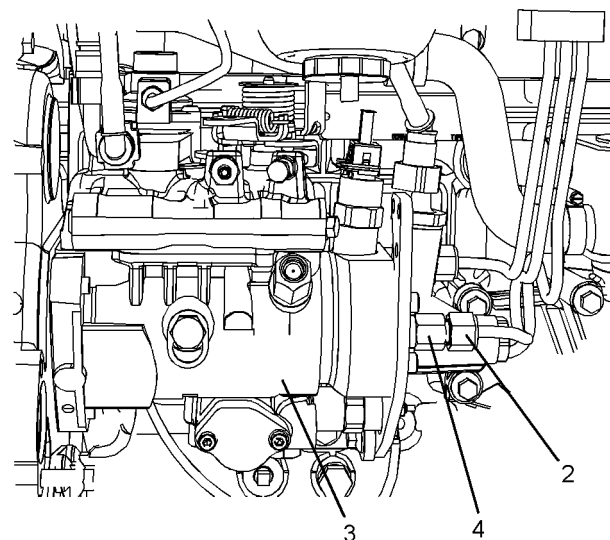


Illustration 6
Typical example

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2. Remove the caps from fuel injection pump (3) and from fuel injectors (1). Remove the caps from fuel injection lines (2).
3. Install fuel injection lines (2). Loosely connect the nuts at both ends of the fuel injection lines.
4. Tighten fuel injection lines (2) at fuel injector (1) to a torque of 27 N·m (19.9141 lb ft).
5. Tighten fuel injection lines (2) at fuel injection pump (3) to 27 N·m (19.9141 lb ft). Ensure that the connection (4) does not turn.

Note: Ensure that each fuel injection line does not contact any other fuel injection line or any other engine component.

6. Install the breather tube to the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".
7. If the engine is equipped with a cover for the fuel injectors, install the cover for the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
8. Turn the fuel supply to the ON position.
9. Turn the battery disconnect switch to the ON position.
10. Remove the air from the fuel system. Refer to the Operations and Maintenance Manual, "Fuel System - Prime".

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Fuel Injector Cover - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

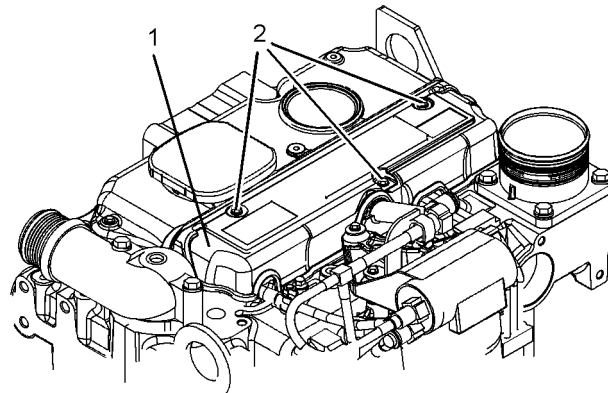


Illustration 7

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Typical example

1. Thoroughly clean all of the outer surfaces of fuel injection cover (1).
2. Remove bolts (2) from fuel injection cover (1).
3. Remove fuel injection cover (1).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

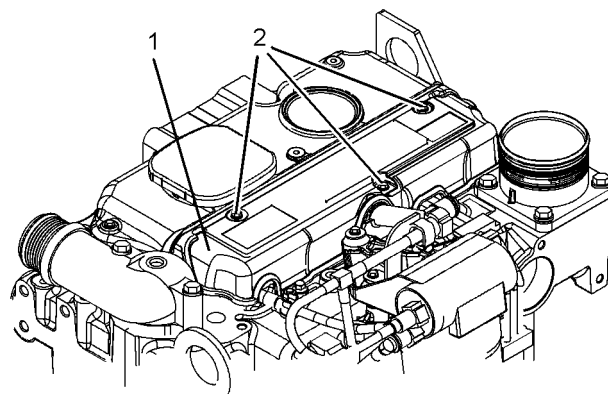


Illustration 8

g01379464

Typical example

1. Ensure that fuel injection cover (1) is clean and free from damage.
2. Install fuel injection cover (1).
3. Install bolts (2). Tighten the bolts to a torque of 9 N·m (80 lb in).

i02746303

Fuel Injection Pump - Remove

Removal Procedure

Table 1

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	27610211	Timing Pin (Crankshaft)	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Put identification marks on all hoses, on all hose assemblies, on wires and on all tube assemblies for installation purposes. Plug all hose assemblies and tube assemblies. This helps to prevent fluid loss and this helps to keep contaminants from entering the system.

1. Turn the fuel supply to the OFF position.
2. Turn the battery disconnect switch to the OFF position.

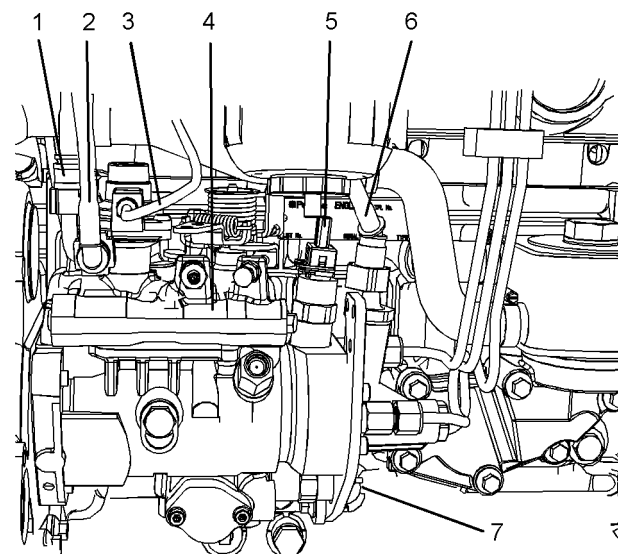


Illustration 9

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Typical example

3. Disconnect plastic tube assembly (1), plastic tube assembly (2) and plastic tube assembly (6) from fuel injection pump (4).
4. Disconnect tube assembly (3) from the fuel injection pump (4).
5. Remove the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove".
6. Disconnect the harness assembly from solenoid (5).
7. Disconnect the harness assembly from solenoid (7).
8. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

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9. Use Tooling (B) in order to lock the camshaft in the correct position. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove" for the correct procedure.

10. Remove the backlash from the fuel pump gear. Lock the fuel injection pump in the correct position and remove the fuel pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove and Install" for the correct procedure.

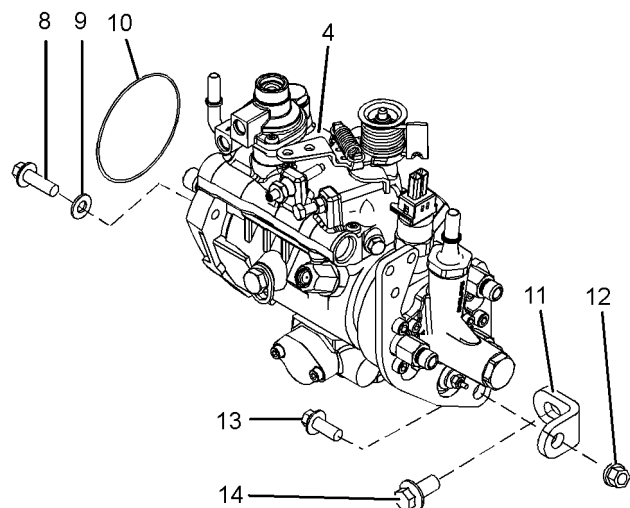


Illustration 10
Typical example

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11. Remove nut (12). Remove bolt (13).

12. Remove bolt (14) and bracket (11) from the cylinder block.

13. Remove bolts (8) and washers (9) in order to remove fuel injection pump (4).

Note: The fuel injection pump should be supported by hand as the bolts are removed.

14. Remove the fuel injection pump from the front housing. Remove O-ring seal (10).

Fuel Injection Pump - Install

Installation Procedure

Table 2

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	27610211	Timing Pin (Crankshaft)	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Inspect the bore in the front housing for damage. If the bore is damaged, replace the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" and Disassembly and Assembly, "Housing (Front) - Install".

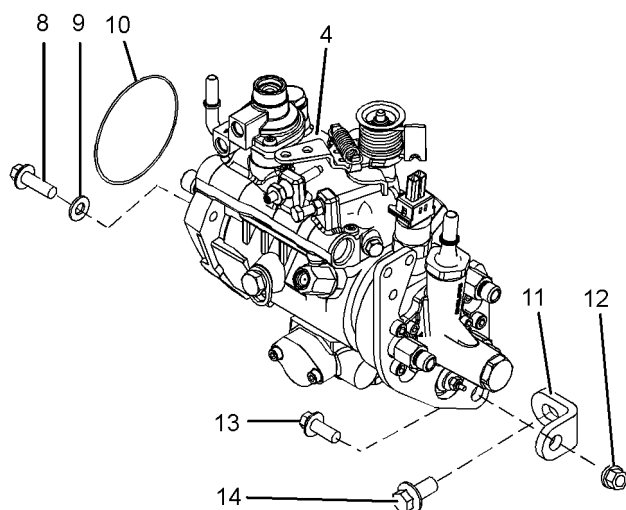


Illustration 11 g01439740

Typical example

2. Install a new O-ring seal (10) onto the fuel injection pump (4).
3. Install new washers (9) to bolts (8).
4. Align the holes in the fuel injection pump with the holes in the front housing. Install the fuel injection pump (4) to the housing.

Note: The fuel injection pump should be supported by hand until the bolts are installed.

5. Install bolts (8). Tighten the bolts to a torque of 25 N·m (18 lb ft).
6. Position support bracket (11) onto the cylinder block. Install bolt (14) finger tight.
7. Install bolt (13) and nut (12) finger tight.
8. Tighten bolt (14) to a torque of 44 N·m (32 lb ft). Tighten bolt (13) and nut (12) to a torque of 22 N·m (16 lb ft).

Note: Ensure that the fuel injection pump is not stressed as the bolts for the bracket are tightened.

9. Ensure that the No. 1 cylinder is at top dead center on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Fuel Injection Timing - Check". If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

10. Use Tooling (B) in order to lock the camshaft in the correct position. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove and Install" for the correct procedure.
11. Install the fuel injection pump gear to fuel injection pump (4). Refer to Disassembly and Assembly, "Fuel Injection Pump Gear - Install" and refer to Disassembly and Assembly, "Gear Group (Front) - Remove and Install".

Note: Ensure that the fuel injection pump is in the unlocked position after the installation of the fuel injection pump gear is completed.

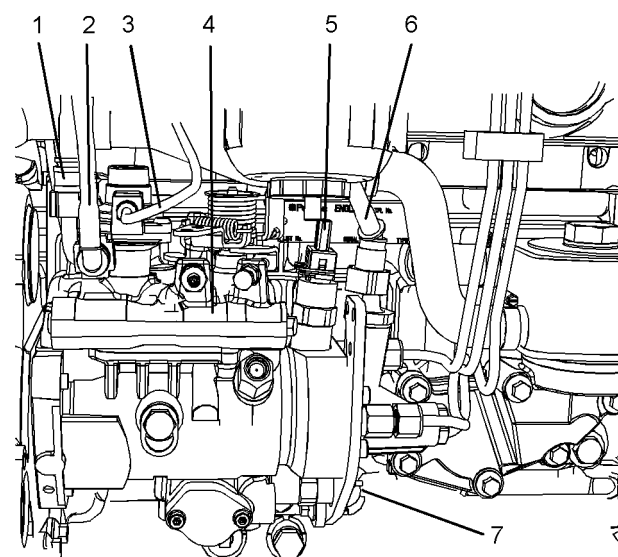


Illustration 12 g01439737

Typical example

12. Remove the plugs and caps from ports and tube assemblies.
13. Connect plastic tube assemblies (1), plastic tube assemblies (2) and plastic tube assemblies (6) to fuel injection pump (4).
14. Connect tube assembly (3) to fuel injection pump (4).
15. Install the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".
16. Connect the harness assembly to solenoid (5).
17. Connect the harness assembly to solenoid (7). Tighten nut (7) to a torque of 4 N·m (35 lb in).

18. Turn the fuel supply to the ON position.
19. Turn the battery disconnect switch to the ON position.

End By:

- a. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

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Fuel Injection Pump Gear - Remove

Removal Procedure

Table 3

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	27610211	Timing Pin (Crankshaft)	1
D	-	Puller (Three Leg)	

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

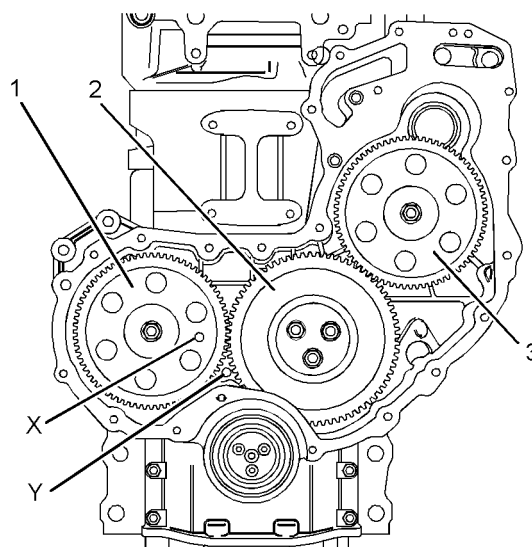


Illustration 13

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Typical example

2. Install Tooling (B) through Hole (X) in camshaft gear (1) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position.
3. Install Tooling (C) into Hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

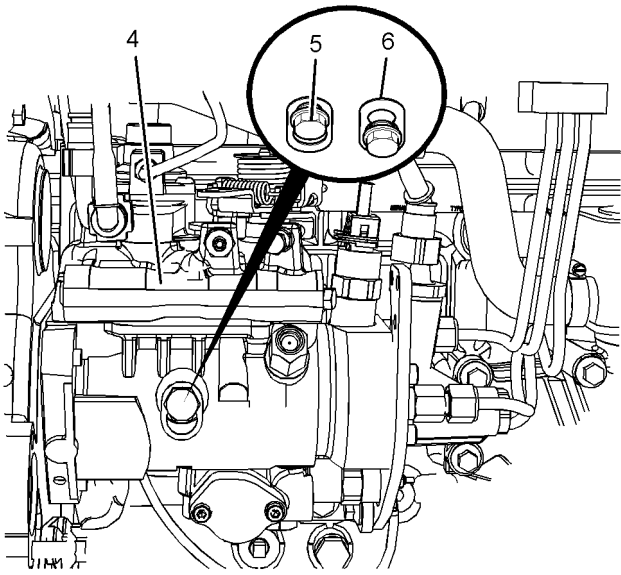


Illustration 14
Typical example

4. Apply sufficient pressure to fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Lock fuel injection pump (4) in this position. Loosen locking screw (5). Rotate spacer (6) in order to allow locking screw (5) to tighten against the shaft of the fuel injection pump. Tighten locking screw (5) to a torque of 14.5 N·m (11 lb ft).

Note: Locking screw (5) must be tightened in order to prevent the shaft of the fuel injection pump from rotating. The shaft of the fuel injection pump must not be rotated after the fuel injection pump has been removed from the engine.

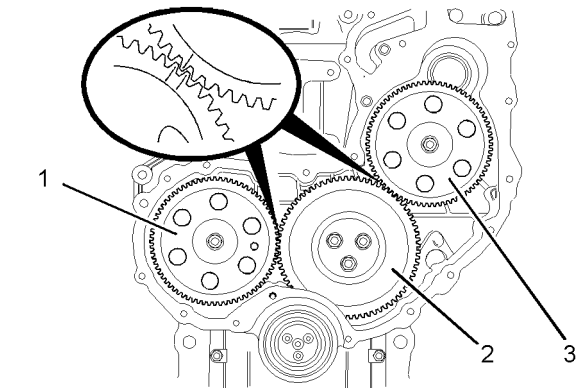


Illustration 15
Alignment of timing Marks

5. Mark gears (1), (2), and (3) in order to show alignment. Refer to Illustration 15.

Note: Identification will ensure that the gears can be installed in the original alignment.

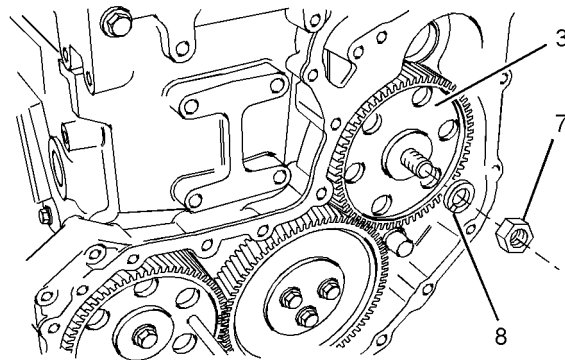


Illustration 16
Typical example

6. Loosen nut (7) on fuel pump gear (3).
7. Install Tooling (D) through three holes in fuel pump gear (3). Tighten Tooling (D) until the fuel pump gear is released.
8. Remove Tooling (D) from fuel pump gear (3).
9. Remove nut (7) and washer (8) from fuel pump gear (3). Remove the fuel pump gear.

i02746306

Fuel Injection Pump Gear - Install

Installation Procedure

Table 4

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	27610211	Timing Pin (Crankshaft)	1
D	-	Magnetic Base	1
	-	Finger Clock	1

- (1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: The fuel injection pump must remain locked until the procedure instructs you to unlock the fuel injection pump.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

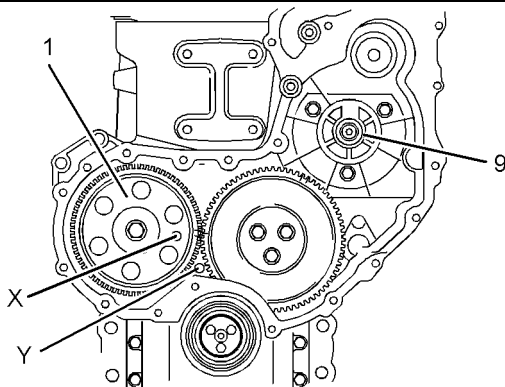


Illustration 17

g01343058

Typical example

2. Ensure that Tooling (C) is installed in Hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

3. Ensure that Tooling (B) is installed into Hole (X) in camshaft gear (1).
4. Ensure that shaft (9) on the fuel injection pump is clean, dry and free from damage.

5. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install".
6. Ensure that the fuel pump gear is clean, dry and free from wear or damage. If necessary, replace the fuel pump gear.

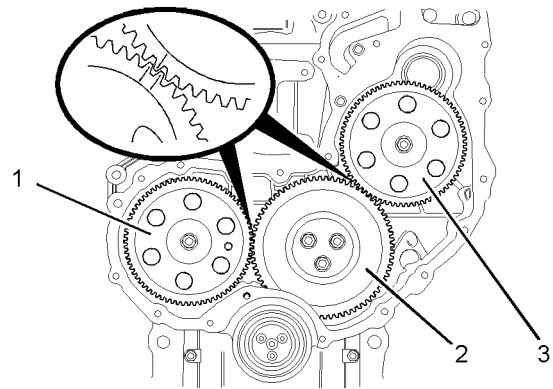


Illustration 18

g01335384

Alignment of timing marks

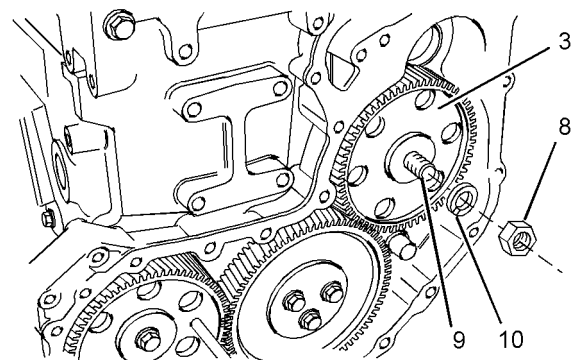


Illustration 19

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Typical example

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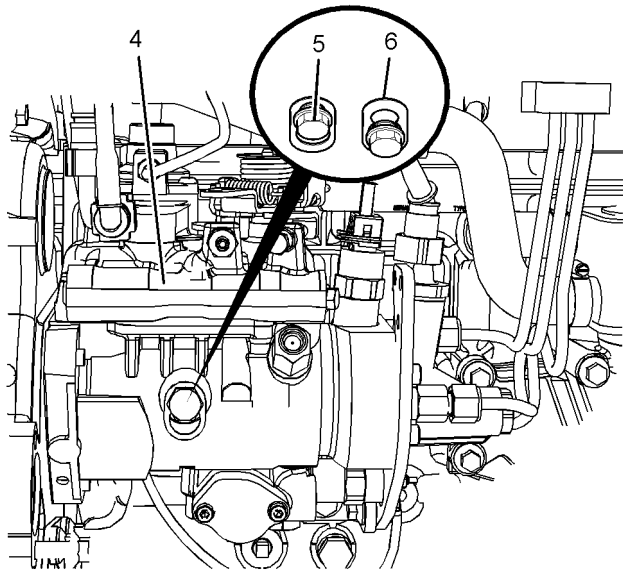


Illustration 20

g01440103

7. Install fuel pump gear (3) to shaft (9) of the fuel injection pump. Ensure that the timing Marks on gears (2) and (3) are in alignment and that the mesh of the gears is correct.
8. Install a new spring washer (10) and install nut (8) to shaft (9) of the fuel injection pump. Apply sufficient pressure to the fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Tighten nut (8) to a torque of 24 N·m (17 lb ft). Unlock the fuel injection pump (5).

In order to unlock the fuel injection pump, loosen locking screw (5) on the fuel injection pump. Rotate spacer (6) in order to allow locking screw (5) to tighten against the spacer. Tighten the locking screw against the spacer to a torque of 12 N·m (106 lb in). This will prevent the locking screw from tightening against the shaft of the fuel injection pump.

9. Remove Tooling (B) and Tooling (C).
10. Tighten nut (8) to a torque of 90 N·m (66 lb ft).
11. Use Tooling (D) to measure the backlash of gears (2) and (3). Ensure that the backlash for the gears is within specified values. Refer to Specifications, "Gear Group (Front)" for further information.
12. Lubricate the teeth of the gears with clean engine oil.

End By:

- a. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

Fuel Injector - Remove

Removal Procedure

Start By:

- a. Remove the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

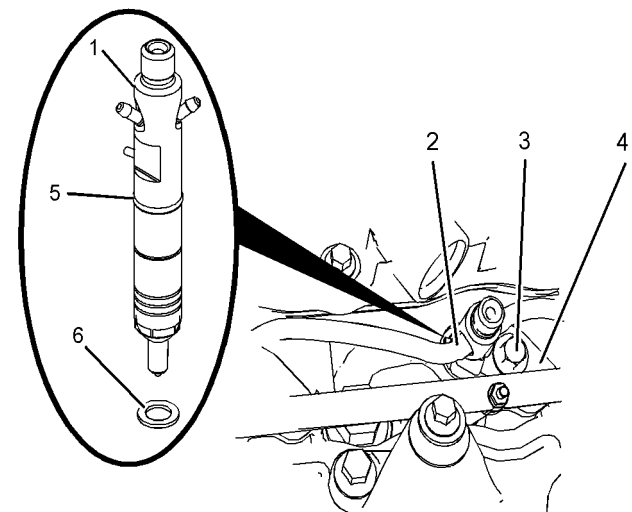


Illustration 21

g01439712

Typical example

1. Remove fuel return lines (2) from fuel injectors (1).
2. Remove bolts (3).
3. Remove clamps (4) from fuel injector (1).

4. Remove fuel injectors (1) from the cylinder head.
Remove O-ring seals (5) from fuel injectors (1).
5. Remove washers (6).

i02746308

Fuel Injector - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

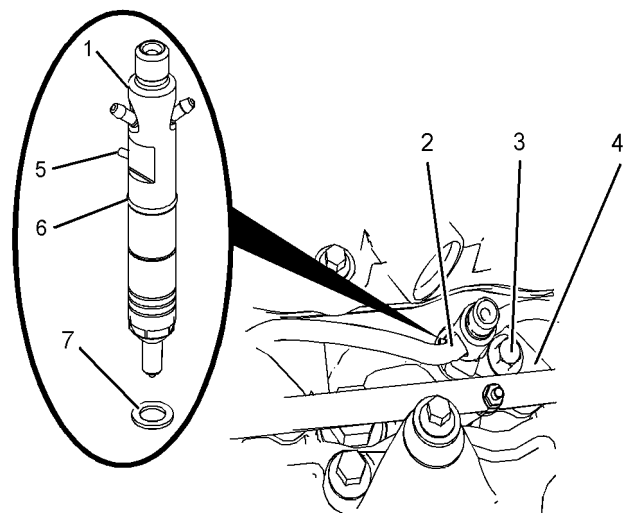


Illustration 22

g01439728

Typical example

1. Ensure that the seat for the fuel injectors in the cylinder head is clean and free from damage. Position a new washer (7) on the seat for the fuel injector in the cylinder head.
2. Install a new O-ring seal (6) on fuel injectors (1).
3. Position clamp (4) onto fuel injectors (1). Install fuel injectors into the cylinder head.

Note: Alignment Pins (5) must be located opposite clamps (4).

4. Install bolts (3). Tighten the bolts to a torque of 35 N·m (26 lb ft).
5. Install fuel return lines (2) to fuel injectors (1).

End By:

- a. Install the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".

i02746309

Turbocharger - Remove

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Plug and cap all open ports and tube assemblies.

1. Loosen the hose clamp and disconnect the air inlet hose from the turbocharger.

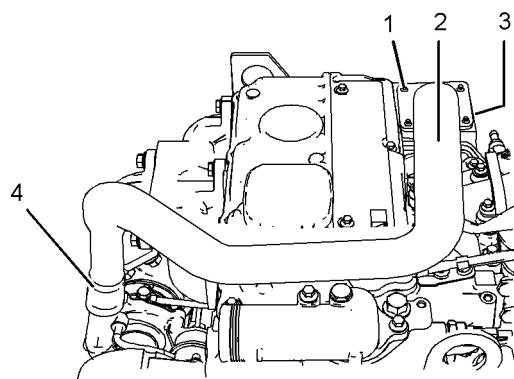


Illustration 23

g01419266

Typical example

2. If the engine is equipped with a air pipe, loosen hose clamp (4) and remove bolts (1). Remove air pipe (2) and remove gasket (3) (not shown) from the cylinder head.

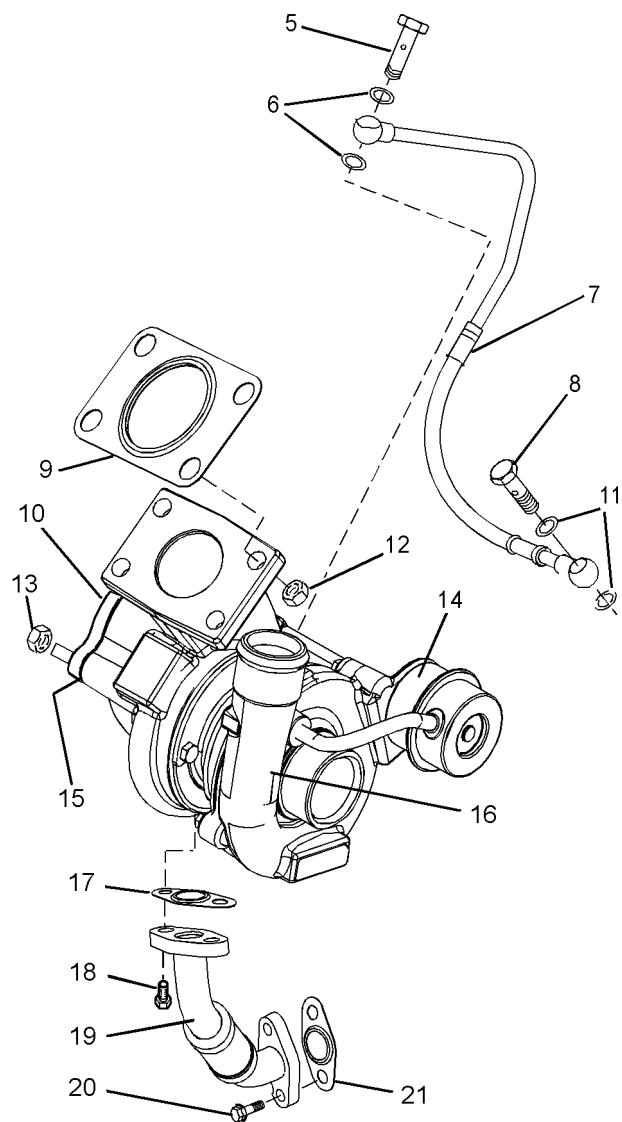


Illustration 24
Typical example

g01380209

3. If the turbocharger is equipped with adapter (10), Remove nuts (13) and remove adapter (10) from turbocharger (16). Remove gasket (15) (not shown).
4. Remove banjo bolt (5) and disconnect tube assembly (7) from turbocharger (16). Remove sealing washers (6) from tube assembly (7).
5. If necessary, remove banjo bolt (8) and disconnect tube assembly (7) from the cylinder block. Remove sealing washers (11) from tube assembly (7). Remove tube assembly (7).
6. Remove bolts (18). Disconnect tube assembly (19) from turbocharger (16). Remove joint (17).

If necessary, remove bolts (20) and remove tube assembly (19) from the cylinder block. Remove joint (21).

7. Remove nuts (12) and remove turbocharger (16).

Note: Do not use the actuator rod (14) to lift the turbocharger.

8. Remove gasket (9).
9. If necessary, remove the studs from the exhaust elbow and the turbocharger.

i02746310

Turbocharger - Install

Installation Procedure

Table 5

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the turbocharger is clean and free from damage. Inspect the turbocharger for wear. Refer to Systems Operation, Testing and Adjusting, "Turbocharger - Inspect" for more information. If the turbocharger is worn, the complete turbocharger must be replaced.

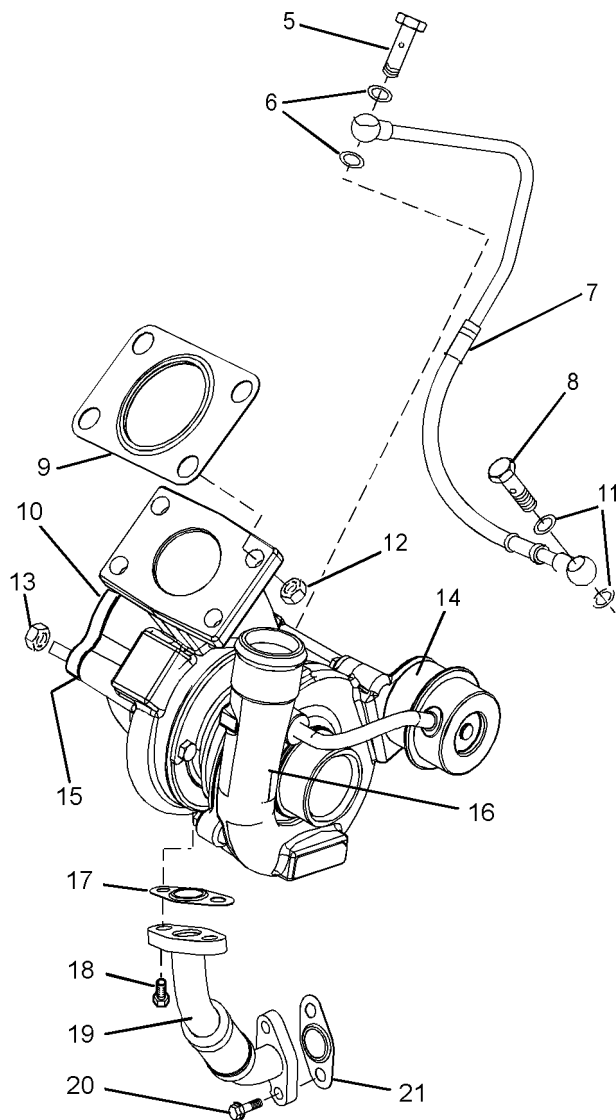


Illustration 25

g01380209

Typical example

2. Test actuator (14) for correct operation. Refer to Systems Operation, Testing and Adjusting, "Turbocharger - Inspect". If the actuator is damaged or the actuator does not operate within the specified limits, the complete turbocharger must be replaced.
3. Clean the mating surfaces of the exhaust elbow. If necessary, install the studs to the exhaust manifold. Tighten the studs to a torque of 18 N·m (13 lb ft).
4. Install a new gasket (9) onto the turbocharger.
5. Position turbocharger (16) onto the exhaust elbow and install nuts (12). Tighten the nuts to a torque of 44 N·m (32 lb ft).

Note: Do not use the actuator rod (14) to lift the turbocharger.

6. If necessary, install tube assembly (19) to the cylinder block. Install a new joint (21) onto tube assembly (19). Position tube assembly onto the cylinder block and install bolts (20) finger tight.
 7. Position a new joint (17) onto tube assembly (19). Install tube assembly to turbocharger (16). Install bolts (18) finger tight.
 8. The turbocharger has different sized bolts (18) and (20). Tighten M6 bolts to a torque of 9 N·m (80 lb in). Tighten M8 bolts to a torque of 22 N·m (16 lb ft).
 9. Lubricate the bearings of turbocharger (16) with clean engine oil through the oil inlet port. Rotate the shaft of the turbocharger in order to distribute the lubricant.
 10. If necessary, Install tube assembly (7). Install new washers (11) and banjo bolt (8) to tube assembly (7). Connect the tube assembly to the cylinder block. Tighten the banjo bolt finger tight.
 11. Position tube assembly (7) onto turbocharger (16). Install new washers (6) and banjo bolt (5) to tube assembly (7). Tighten the banjo bolt finger tight.
 12. Tighten banjo bolts (5) and (8) to a torque of 20 N·m (15 lb ft).
- Note:** Ensure that the tube assembly does not come into contact with any other engine components.
13. If the turbocharger was equipped with an adapter (10), install a new gasket (15) (not shown) and position the adapter (10) onto the turbocharger. Install nuts (13). Tighten the nuts to a torque of 44 N·m (33 lb ft).

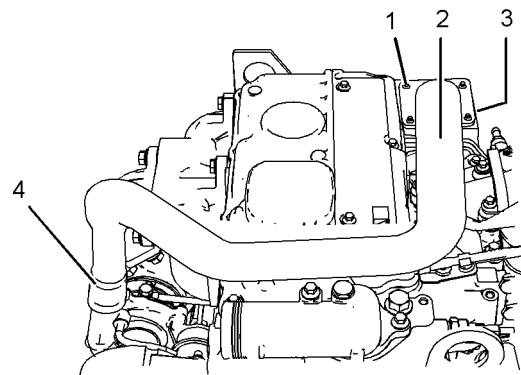


Illustration 26

g01419266

14. If the engine was equipped with an air pipe, install air pipe (2) and a new gasket (3) (not shown) to the cylinder head. Apply Tooling (A) to bolts (1) for the air pipe. Install bolts, and tighten the bolts to a torque of 22 N·m (16 lb ft).

15. Tighten hose clamps (4) securely.

Note: If the air outlet hose has a reflective heat shield, ensure that the reflective heat shield is installed toward the engine.

16. Connect the air inlet hose to the turbocharger.

i02746311

Exhaust Manifold - Remove and Install

Removal Procedure

Start By:

- a. Remove the turbocharger. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".

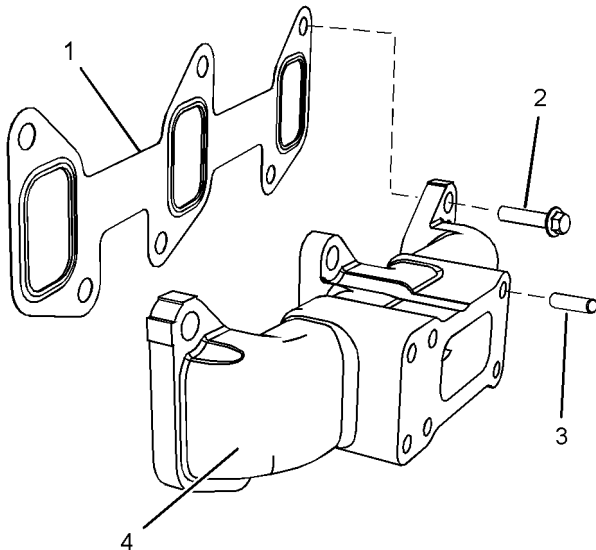


Illustration 27
Typical example

g01379844

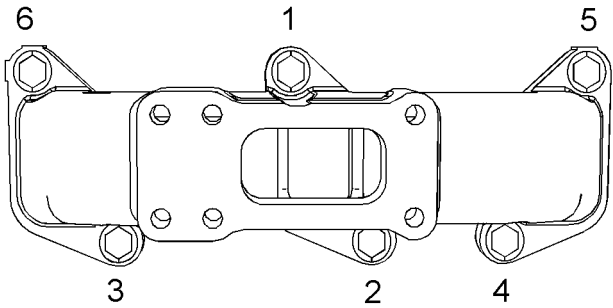


Illustration 28

g01379542

Sequence for loosening the exhaust manifold

1. Loosen bolts (2) in reverse numerical order to the sequence that is shown in Illustration 28.

Note: This will help prevent distortion of the exhaust manifold.

2. Remove bolts (2).
3. Remove exhaust manifold (4).
4. Remove exhaust manifold gasket (1).
5. If necessary, remove studs (3) from exhaust manifold (4).

Installation Procedure

Table 6

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt M10 by 100 mm	2

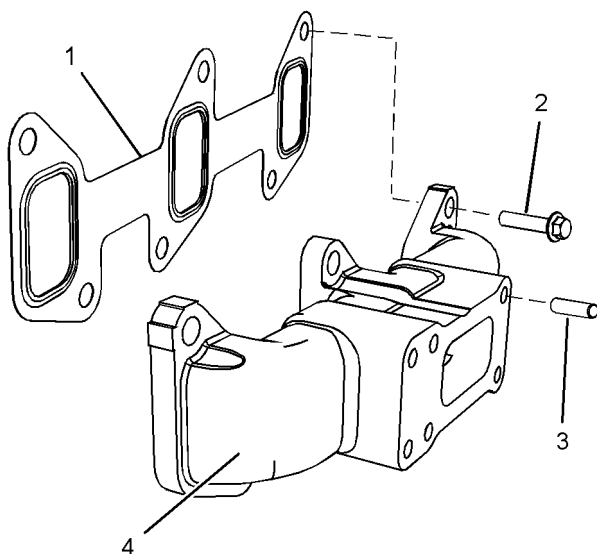


Illustration 29

g01379844

Typical example

1. Ensure that the exhaust manifold is clean and free from damage. Clean the joint face of the cylinder head.
2. If necessary, install studs (3) to exhaust manifold (4). Tighten the studs to a torque of 18 N·m (13 lb ft).

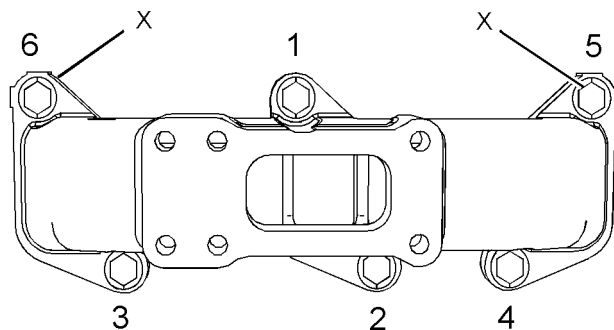


Illustration 30

g01379898

Tightening sequence for the exhaust manifold

3. Install Tooling (A) to the cylinder head in Positions (X). Refer to Illustration 30.
4. Position a new exhaust manifold gasket (1) onto Tooling (A).

Note: Ensure that the exhaust manifold gasket is correctly oriented.

5. Align exhaust manifold (4) with Tooling (A). Install the exhaust manifold to the cylinder head.
6. Loosely install new bolts (2).

7. Remove Tooling (A). Loosely install the remaining bolts (2).

8. Tighten bolts (2) to a torque of 40 N·m (30 lb ft) in the sequence that is shown in Illustration 30.

End By:

- a. Install the turbocharger. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".

i02746313

Exhaust Elbow - Remove and Install

Removal Procedure

Start By:

- a. Remove the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove".

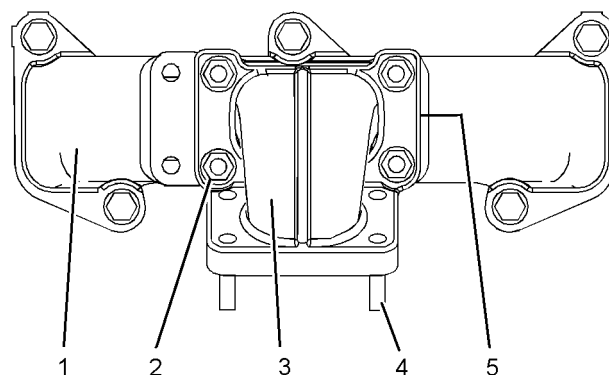


Illustration 31

g01379912

Typical example

1. Remove nuts (2).
2. Remove exhaust elbow (3) from exhaust manifold (1).
3. Remove gasket (5) (not shown) from the exhaust manifold.
4. If necessary, remove studs (4) from exhaust elbow (3).

Installation Procedure

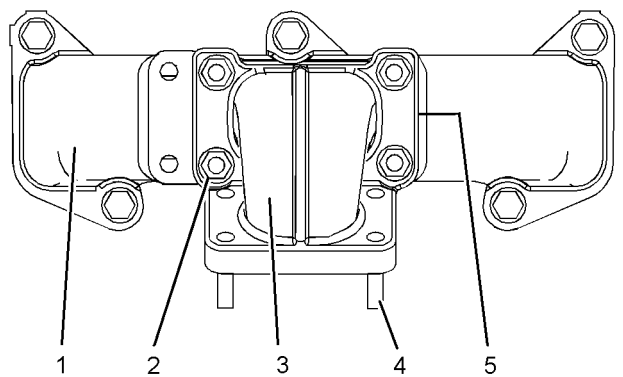


Illustration 32

g01379912

Typical example

1. Ensure that exhaust manifold (1) and exhaust elbow (3) are clean and free from damage.
2. If necessary, install studs (4) to exhaust elbow (3). Tighten the studs to a torque of 18 N·m (13 lb ft).
3. Position a new gasket onto exhaust manifold (1).
4. Install exhaust elbow (3) onto exhaust manifold (1).
5. Install nut (2) to the exhaust manifold. Tighten the nuts to a torque of 44 N·m (32 lb ft).

End By:

- a. Install the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install".

Inlet and Exhaust Valve Springs - Remove and Install

i02746314

Removal Procedure

Table 7

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	21825739	Valve Spring Compressor	1
	27610235	Adapter	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The following procedure should be adopted in order to remove the valve springs when the cylinder head is installed to the engine. Refer to Disassembly and Assembly, "Inlet and Exhaust Valves - Remove and Install" for the procedure to remove the valve springs from a cylinder head that has been removed from the engine.

Note: Ensure that the appropriate piston is at the top center position before the valve spring is removed. Failure to ensure that the piston is at the top center position may allow the valve to drop into the cylinder bore.

NOTICE

Plug the apertures for the push rods in the cylinder head in order to prevent the entry of loose parts into the engine.

NOTICE

Ensure that the valve spring is compressed squarely or damage to the valve stem may occur.

1. Follow Steps 1.a through 1.d in order to position the appropriate piston at top center.
 - a. Install Tooling (B) and Tooling (C) in position on the cylinder head in order to compress a valve spring for the appropriate piston.
 - b. Use Tooling (B) and Tooling (C) in order to compress valve spring (3) and open the valve slightly.

Note: Do not compress the spring so that the valve spring retainer (2) touches the valve stem seal.

- c. Use Tooling (A) in order to rotate the crankshaft carefully, until the piston touches the valve.

Note: Do not use excessive force to turn the crankshaft. The use of force can result in bent valve stems.

- d. Continue to rotate the crankshaft and gradually release the pressure on Tooling (B) and Tooling (C) until the piston is at the top center position. The valve is now held in a position that allows the valve spring to be safely removed.

NOTICE

Do not turn the crankshaft while the valve springs are removed.

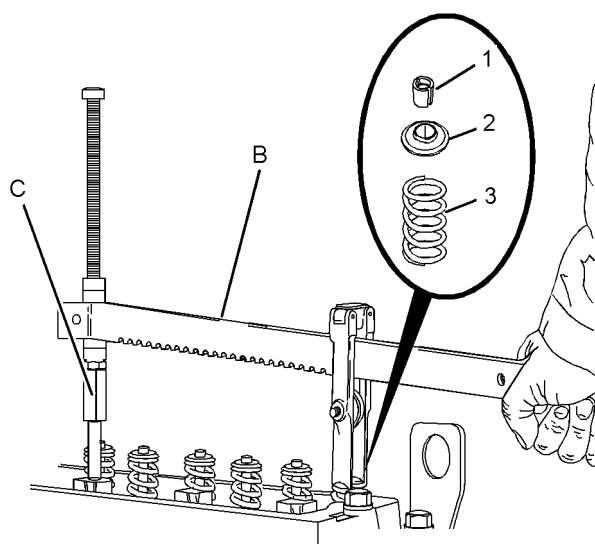


Illustration 33
Typical example

g01430292

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

2. Apply sufficient pressure to Tooling (B) and Tooling (C) in order to allow removal of the valve keepers (1). Remove valve keepers (1).

Note: Do not compress the spring so that the valve spring retainer (2) touches the valve stem seal.

3. Slowly release the pressure on Tooling (B) and Tooling (C).
4. Remove valve spring retainer (2) and remove valve spring (3).
5. If necessary, remove the valve stem seals.
6. Repeat Steps 2 through 5 in order to remove the remaining valve spring from the appropriate cylinder.
7. Remove Tooling (B) and Tooling (C).

Installation Procedure

Table 8

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	21825739	Valve Spring Compressor	1
	27610235	Adapter	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Do not turn the crankshaft while the valve springs are removed.

1. Inspect the valve springs for the correct length. Refer to Specifications, "Cylinder Head Valves " for more information.
2. If necessary, install a new valve stem seal onto the valve guide.

Note: The outer face of the valve guide must be clean and dry before installing the valve stem seal.

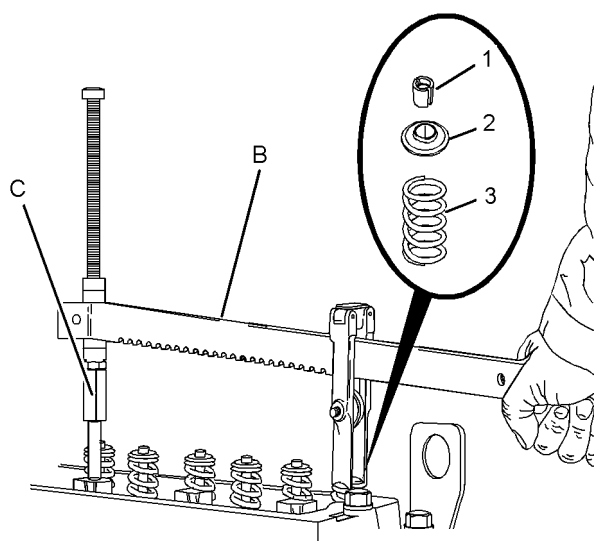


Illustration 34
Typical example

g01430292

WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

3. Install valve spring (3) onto the cylinder head. Position valve spring retainer (2) onto valve spring (3).
4. Install Tooling (B) and Tooling (C) in the appropriate position on the cylinder head in order to compress the valve spring.

NOTICE

Ensure that the valve spring is compressed squarely or damage to the valve stem may occur.

5. Apply sufficient pressure to Tooling (B) and Tooling (C) in order to install valve keepers (1). Install the valve spring keepers (1).

Note: Do not compress the spring so that valve spring retainer (2) touches the valve stem seal .

6. Carefully release the pressure on Tooling (B) and Tooling (C).

Note: Ensure that the valve keepers are correctly seated.

7. Repeat Steps 2 to 6 for the remaining valves.

WARNING

The valve spring keepers can be thrown from the valve when the valve spring compressor is released. Ensure that the valve spring keepers are properly installed on the valve stem. To help prevent personal injury, keep away from the front of the valve spring keepers and valve springs during the installation of the valves.

8. Remove Tooling (B) and Tooling (C).

End By:

- a. Install the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Install".

i02746315

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 9

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1

Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the bottom face of the cylinder head.
Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications, "Cylinder Head Valves" for the correct dimensions.
2. Place a temporary identification mark on the heads of the valves in order to identify the correct position. Inlet valves have a recess in the center of the head.

Note: Do not stamp the heads of the valve. Stamping or punching the heads of the valves could cause the valves to fracture.

3. Use a suitable lifting device to position the cylinder head with the valve springs upward. The weight of the cylinder head is approximately 56 kg (125 lb).

Note: Ensure that the cylinder head is kept on a clean, soft surface in order to prevent damage to the machined face.

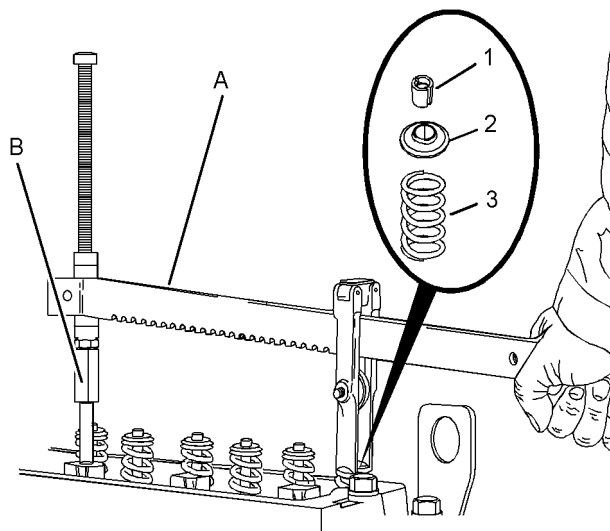


Illustration 35
Typical example

g01430303

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

4. Install Tooling (A) in position on the cylinder head in order to compress the appropriate valve spring.

NOTICE

Ensure that the valve spring is compressed squarely or damage to the valve stem may occur.

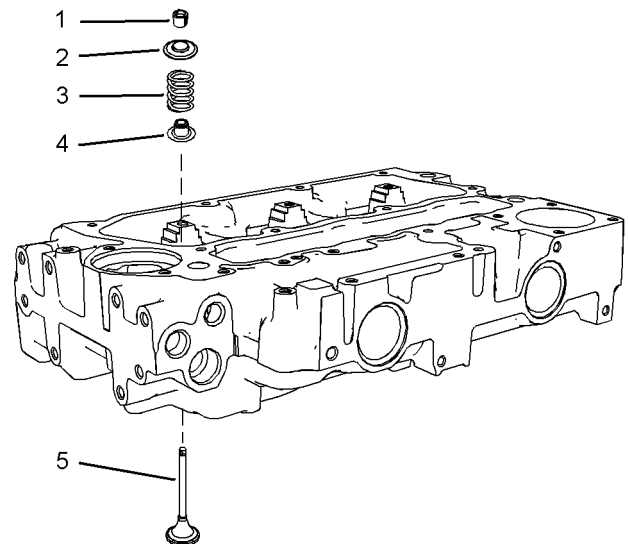


Illustration 36
Typical example

g01380536

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

5. Apply sufficient pressure to Tooling (A) in order to remove valve keepers (1).

Note: Do not compress the spring so that valve spring retainer (2) touches valve stem seal (4).

6. Slowly release the pressure on Tooling (A).

7. Remove valve spring retainer (2). Remove valve spring (3).
8. Repeat Steps 4 to 7 for the remaining valves.
9. Remove Tooling (A).
10. Remove valve stem seals (4).
11. Use a suitable lifting device to carefully turn over the cylinder head.
12. Remove valves (5).

Installation Procedure

Table 10

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean all components of the cylinder head assembly. Ensure that all ports, all coolant passages and all lubrication passages in the cylinder head are free from debris. Follow Steps 1.a through 1.e in order to inspect the components of the cylinder head assembly. Replace any components that are worn or damaged.
 - a. Inspect the cylinder head for wear and for damage. Refer to Systems Operation, Testing and Adjusting, "Cylinder Head Inspect".
 - b. Inspect the valve seats for wear and for damage. Refer to Specifications, "Cylinder Head Valves" for further information.
 - c. Inspect the valve guides for wear and for damage. Refer to Specifications, "Cylinder Head Valves" and Systems Operation, Testing and Adjusting, "Valve Guide - Inspect" for further information.
 - d. Inspect the valves for wear and for damage. Refer to Specifications, "Cylinder Head Valves".
 - e. Inspect the valve springs for the correct length. Refer to Specifications, "Cylinder Head Valves".

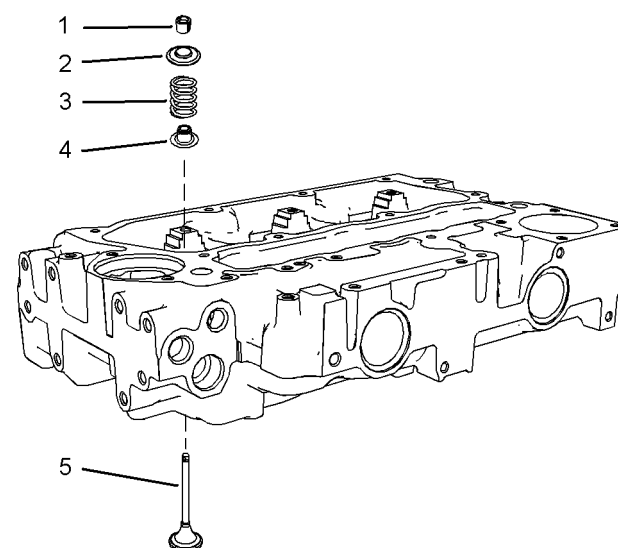


Illustration 37

g01380536

2. Lubricate the stems of valves (5) with clean engine oil. Install valves (5) in the appropriate positions in the cylinder head. Check the depth of the valves below the face of the cylinder head. Refer to Systems Operation, Testing and Adjusting, "Valve Depth - Inspect" for more information.
 3. Use a suitable lifting device to carefully turn over the cylinder head. The weight of the cylinder head is approximately 56 kg (125 lb).
- Note:** Ensure that all of the valves remain in place.
4. Install new valve stem seals (4) onto each of the valve guides.
- Note:** The outer face of the valve guides must be clean and dry before installing the valve stem seals.
5. Install valve spring (3) onto the cylinder head. Position valve spring retainer (2) onto valve spring (3).

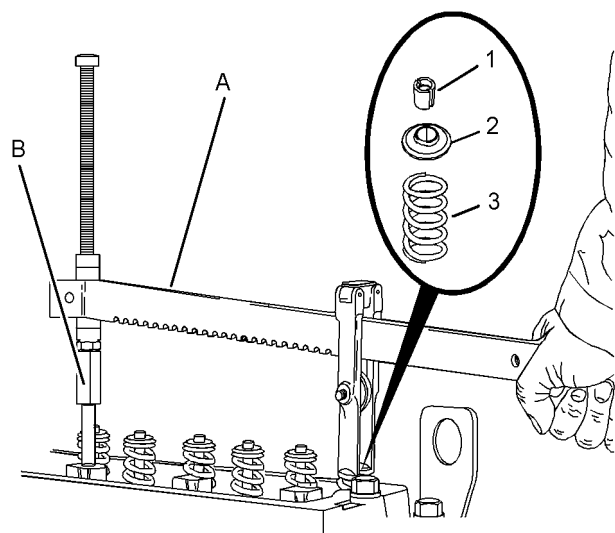


Illustration 38

g01430303

Typical example

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

6. Install Tooling (A) in the appropriate position on the cylinder head in order to compress valve spring (3).

NOTICE

Ensure that the valve spring is compressed squarely or damage to the valve stem may occur.

7. Apply sufficient pressure to Tooling (A) in order to install valve keepers (1).

Note: Do not compress the spring so that valve spring retainer (2) touches valve stem seal (4).

WARNING

The valve spring keepers can be thrown from the valve when the valve spring compressor is released. Ensure that the valve spring keepers are properly installed on the valve stem. To help prevent personal injury, keep away from the front of the valve spring keepers and valve springs during the installation of the valves.

8. Carefully release the pressure on Tooling (A).

9. Repeat Steps 5 to 8 for the remaining valves.

10. Remove Tooling (A) from the cylinder head.

11. Use a suitable lifting device to position the cylinder head on a support. Ensure that the heads of the valves are not obstructed. Lightly strike the top of the valves with a soft hammer in order to ensure that valve keepers (1) are properly installed.

End By:

- a. Install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".

i02746316

Inlet and Exhaust Valve Guides - Remove and Install

Removal Procedure

Table 11

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825478	Valve Guide Remover/Replacer	1
	21825479	Valve Guide Adapter	1

Start By:

- a. Remove the inlet valves and the exhaust valves. Refer to Disassembly and Assembly, "Inlet and Exhaust Valves - Remove and Install".

NOTICE

Removal and installation of the valve guide and valve seat must be carried out by personnel with the correct training. Also special machinery is required. For more information, refer to your authorized Perkins distributor.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

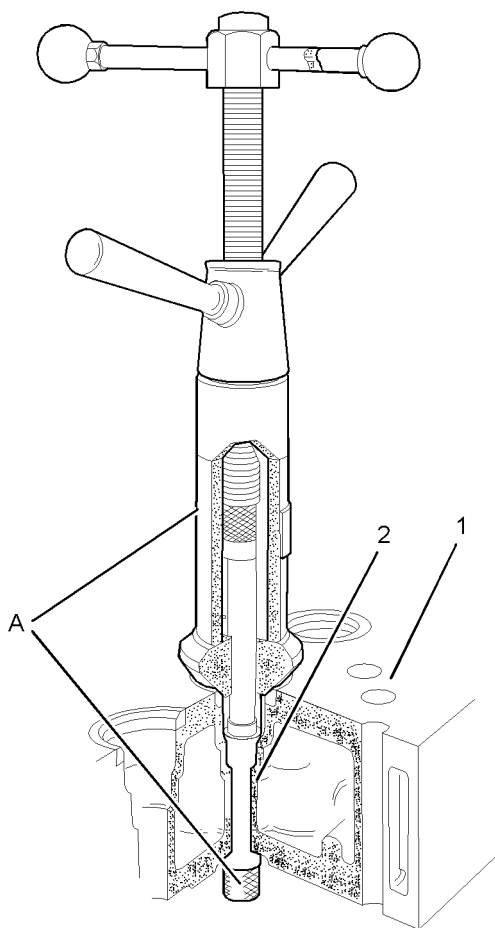


Illustration 39

g01326234

1. Use Tooling (A) in order to remove valve guides (2) from cylinder head (1).
2. Repeat the Step 1 for the remaining valve guides.

Installation Procedure

Table 12

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825478	Valve Guide Remover/Replacer	1
	21825479	Valve Guide Adapter	1
B	27610030	Valve Guide/Valve Seat Reamer/Cutter	1

NOTICE

Removal and installation of the valve guide and valve seat must be carried out by personnel with the correct training. Also special machinery is required. For more information, refer to your authorized Perkins distributor.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the parent bores in the cylinder head for the valve guides.

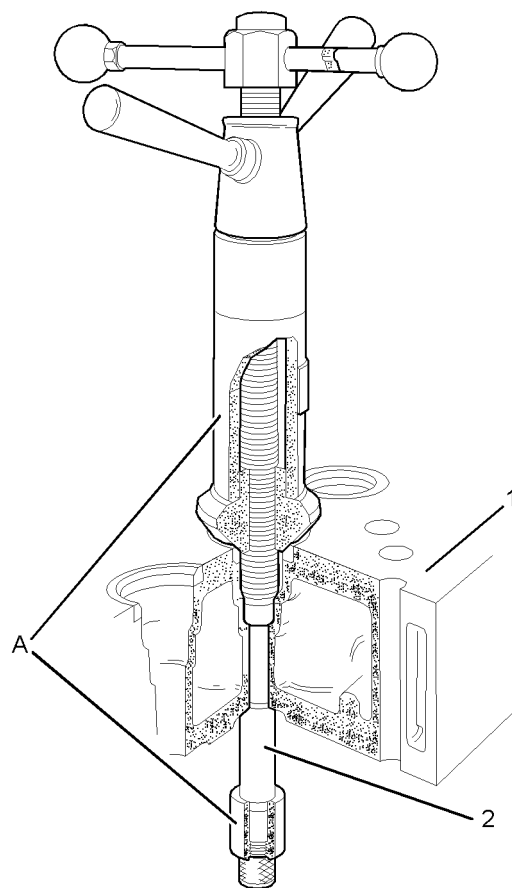


Illustration 40

g01326240

2. Lubricate a new valve guide (2) and place the valve guide in position. Carefully tap the valve guide in order to start the installation. Use Tooling (A) to install the valve guide into the cylinder head.
3. Repeat Step 2 for the remaining valve guides.

i02746317

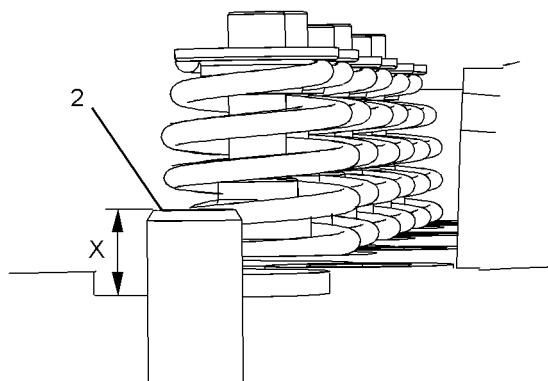


Illustration 41

g01383769

4. Check Protrusion (X) of valve guides (2). The valve guides should protrude $12.5 \pm .15$ mm (0.492 ± 0.006 inch) above the valve spring recess. Refer to Specifications, "Cylinder Head Valves" for more information.
5. After installation of valve guides (2), the valve guides must be reamed and the valve seat inserts must be cut to the finished diameter. Follow Steps 5.a through 5.d in order to ream the valve guides and cut the valve seat inserts.
 - a. Lubricate the bores of valve guides (2) with clean engine oil.
 - b. Use Tooling (B) in order to ream the valve guides. Ensure that even pressure is applied to Tooling (B).
 - c. Use Tooling (B) in order to cut the valve seats. Ensure that even pressure is applied to Tooling (B).
 - d. Ensure that the cylinder head is clean and free from machining debris.
6. Check the finished diameter of valve guides (2). Refer to Specifications, "Cylinder Head - Valves" for more information.
7. Check the depths of the valves below the face of the cylinder head. Refer to System Operation, Testing and Adjusting, "Valve Depth - Inspect" for more information.

End By:

- a. Install the inlet valves and the exhaust valves. Refer to this Disassembly and Assembly Manual, "Inlet and Exhaust Valves - Remove and Install".

Engine Oil Filter Base - Remove and Install

Removal Procedure

Table 13

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Strap Wrench As	1

Note: The oil filter may be installed vertically or the oil filter may be installed horizontally.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

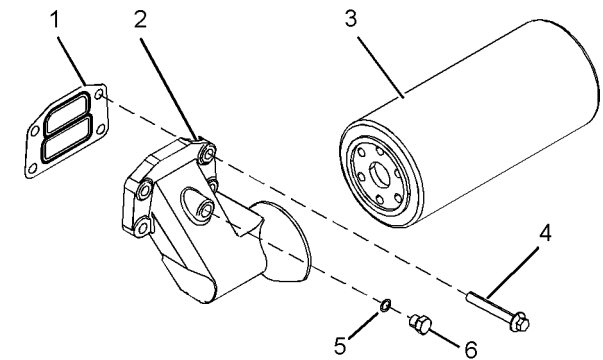


Illustration 42

g01343554

Typical example

1. Use Tooling (A) to remove engine oil filter (3). Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change".
2. Remove bolts (4) and remove engine oil filter base (2).
3. Remove joint (1).

4. If the engine oil filter base has a spacer plate, remove the spacer plate and remove the joint.

Note: Mark the orientation of the spacer plate.

5. If necessary, remove plug (6) from engine oil filter base (2). Remove O-ring seal (5) from the plug.

Installation Procedure

Table 14

Required Tools			
Tool	Part Number	Part Description	Qty
B	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

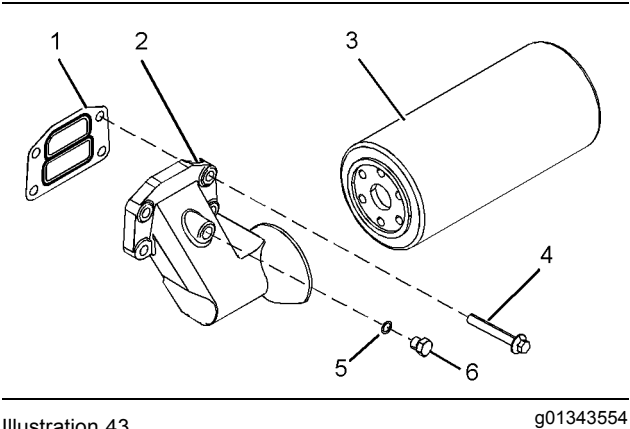


Illustration 43

g01343554

Typical example

1. Ensure that the engine oil filter base is clean. Clean the mating surfaces of the cylinder block.
2. If necessary, install a new O-ring seal (5) to plug (6). Install plug (6) to engine oil filter base (2). Tighten the plug to a torque of 12 N·m (106 lb in).
3. Install bolts (4) to engine oil filter base (2).
4. Install a new joint (1) onto bolts (4). If the engine oil filter base has a spacer plate, install the spacer plate and a new joint onto the bolts.

Note: Ensure the correct orientation of spacer plate.

5. Apply Tooling (B) to the threads of the bolts. Install the assembly of the engine oil filter base to the cylinder block.

6. Tighten bolts (4) to a torque of 22 N·m (16 lb ft).

7. Install a new engine oil filter (3). If necessary, fill the engine oil pan to the correct level that is indicated on the oil level gauge. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check".

i02746318

Engine Oil Cooler - Remove

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Drain the engine lubricating oil into a suitable container. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.
3. If necessary, remove the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

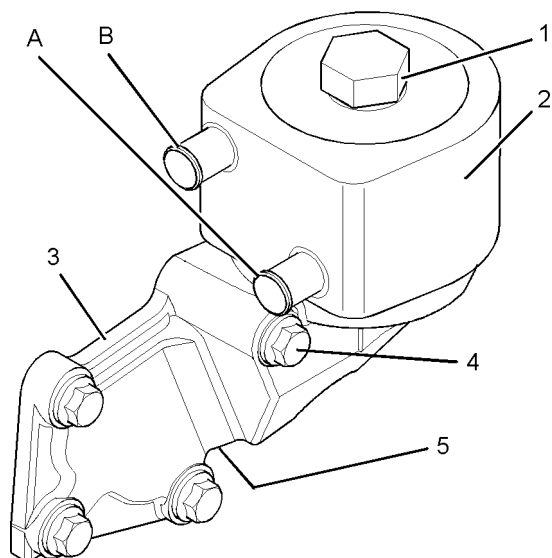


Illustration 44
Typical example

g01380914

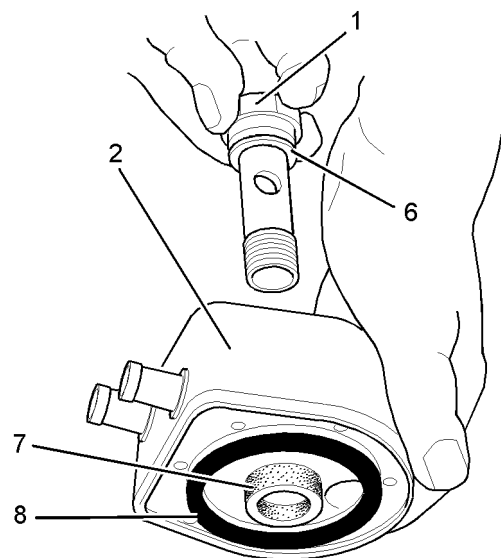


Illustration 45

g01380957

4. Disconnect the hoses from Connections (A) and hoses from Connections (B) on oil cooler body (2).
5. Loosen banjo bolt (1) from oil cooler body (2).
6. Remove oil cooler body (2) from adapter (3).
7. Remove O-ring seal (7) and O-ring seal (8) from oil cooler (2).
8. Remove banjo bolt (1) from the oil cooler body.
9. Remove sealing washer (6) from banjo bolt (1).

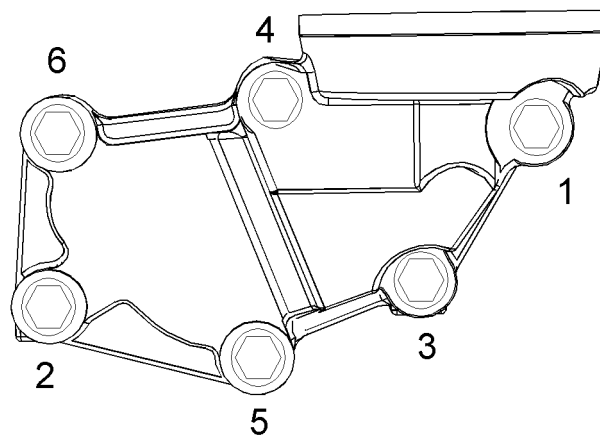


Illustration 46

g01380915

Sequence for loosening the engine oil cooler

10. Loosen bolts (4) in reverse numerical order to the sequence that is shown in Illustration 46. Remove bolts (4). Support adapter (3) as the bolts are removed.

Note: Bolts (4) are different lengths. Note the correct position of the bolts. Note the position of any brackets that are secured by the bolts.

11. Remove adapter (3) from the cylinder block.

12. Remove joint (5) (not shown).

i02746319

Engine Oil Cooler - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

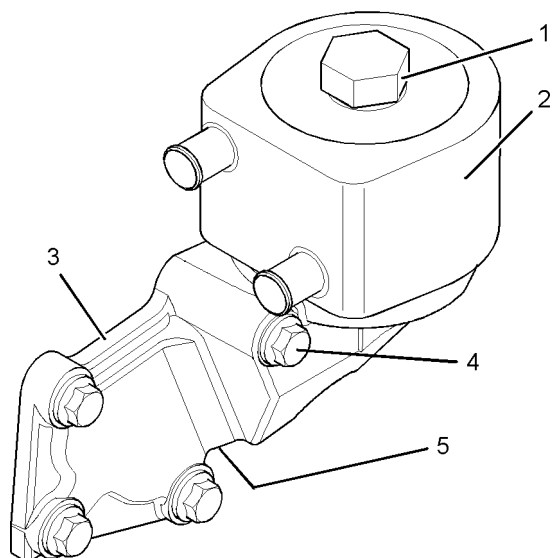


Illustration 47
Typical example

g01444650

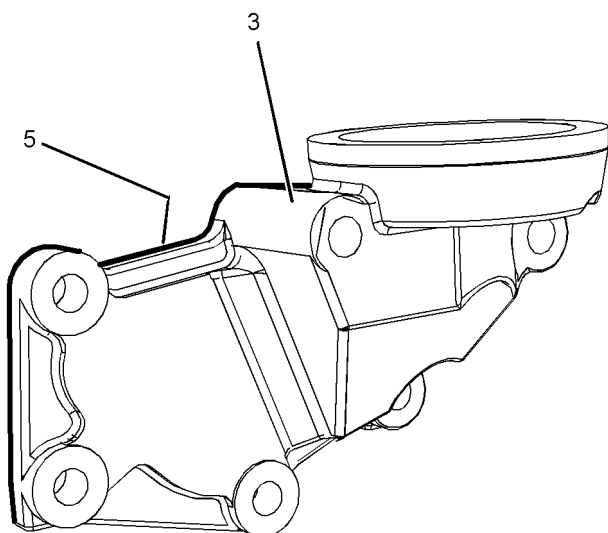


Illustration 48
Typical example

g01381216

1. Ensure that adapter (3) of the engine oil cooler is clean and free from damage. Clean the mating surfaces of the cylinder block.
2. Position a new joint (5) (not shown) onto adapter (3). Install bolts (4) to the adapter.
3. Install adapter (3) to the cylinder block. Tighten bolts (4) finger tight.

Note: The bolts are different lengths. Ensure that the different bolts are installed in the correct location. Ensure that any brackets that are secured by the bolts are installed in the correct location.

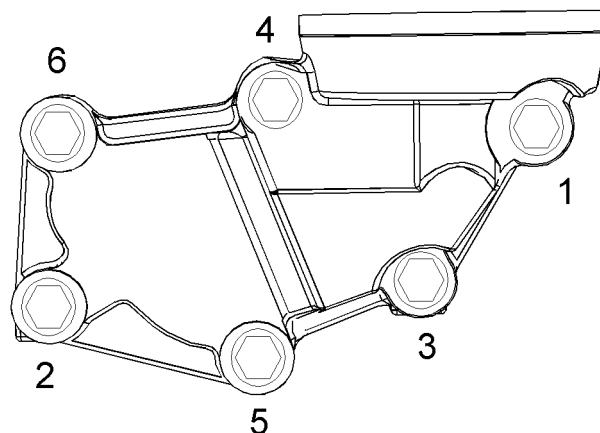


Illustration 49

g01380915

Tightening sequence for the engine oil cooler

4. Tighten bolts (4) to a torque of 22 N·m (16 lb ft). Tighten the bolts in the sequence that is shown in Illustration 49.

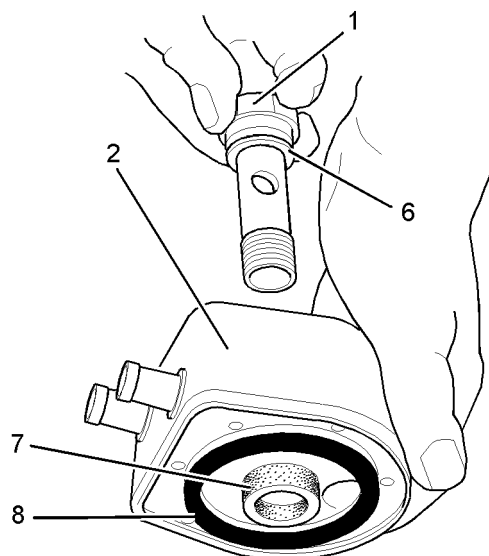


Illustration 50

g01380957

5. Install a new sealing washer (6) to banjo bolt (1).
6. Install new O-ring seal (7) and O-ring seal (8) to oil cooler body (2).
7. Install banjo bolt (3) to oil cooler body (4).

i02746320

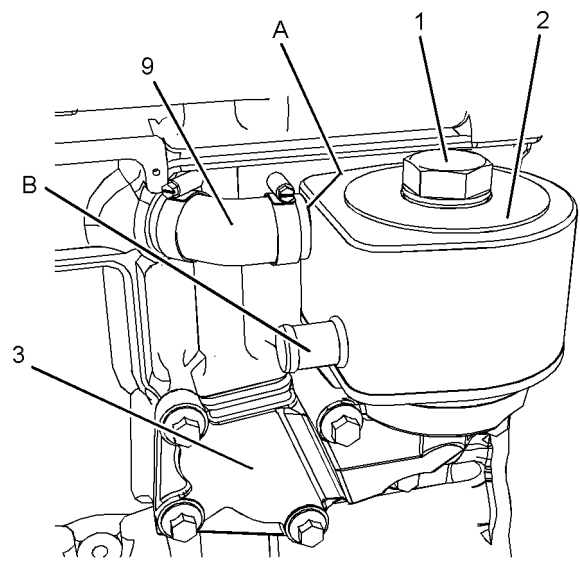


Illustration 51
Typical example

- 8. Install the assembly of oil cooler body (2) to the adapter (3). Align the Connection (A) (not shown) with hose (9) and tighten hose clamps securely. Tighten the banjo bolt (1) to a torque of 57 N·m (42 lb ft).
- 9. Connect the hose to Connections (B) to the assembly of oil cooler (2) and tighten hose clamp securely.
- 10. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
- 11. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, "Engine Oil Filter and Change" for the correct procedure.
- 12. If necessary, Install the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

Engine Oil Relief Valve - Remove and Install

Removal Procedure

Table 15

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Telescoping Magnet	1

Start By:

- a. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

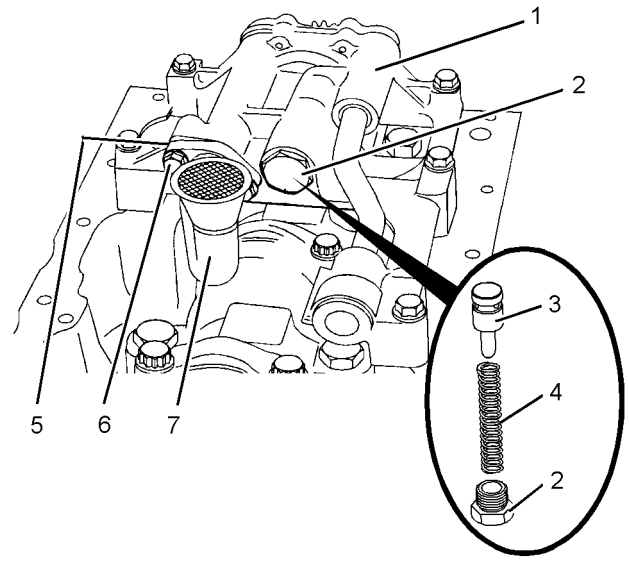


Illustration 52
Typical example

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

1. Remove bolts (6) and suction pipe (7).
2. Remove the joint from suction pipe (5) (not shown).
3. Loosen cap (2). Carefully remove cap (2) from the housing of engine oil pump (1).

Note: The spring force will be released when the cap is removed.

4. Remove spring (4) from the bore for the relief valve in the housing of engine oil pump (1).
5. Use Tooling (A) to remove plunger (3) from the bore for the relief valve in the housing of engine oil pump (1).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

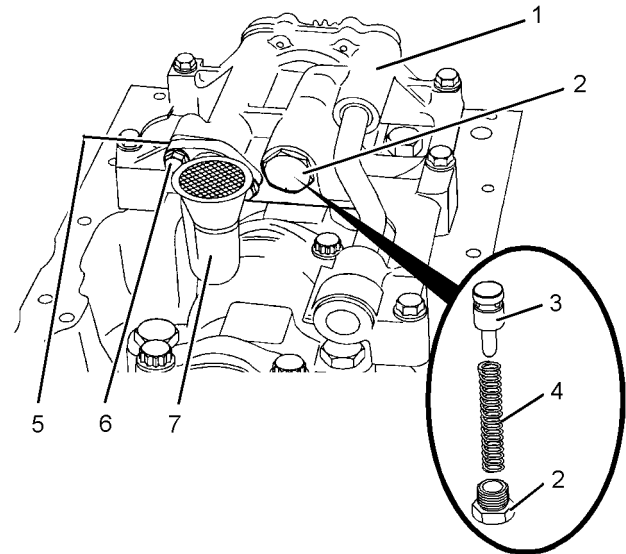


Illustration 53
Typical example

g01343561

WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged. If the bore for the relief valve in the housing of engine oil pump (1) is worn or damaged, the complete assembly of the engine oil pump must be replaced.
2. Lubricate plunger (3) with clean engine oil. Use long nose pliers to install plunger (3) and spring (4) into the bore for the relief valve in the housing of engine oil pump (1).

Note: The plunger must slide freely in the bore for the relief valve.

3. Install cap (2) to engine oil pump (1). Tighten the cap to a torque of 45 N·m (33 lb ft).

Note: Ensure that the spring is properly located inside the plunger and the cap.

4. Install suction pipe (7) and a new joint (5) (not shown) to the assembly of the engine oil pump.
5. Install bolts (6). Tighten the bolts to a torque to 22 N·m (16 lb ft).

End By:

- a. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

i02747705

Engine Oil Pump - Remove and Install

Removal Procedure

Start By:

- a. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

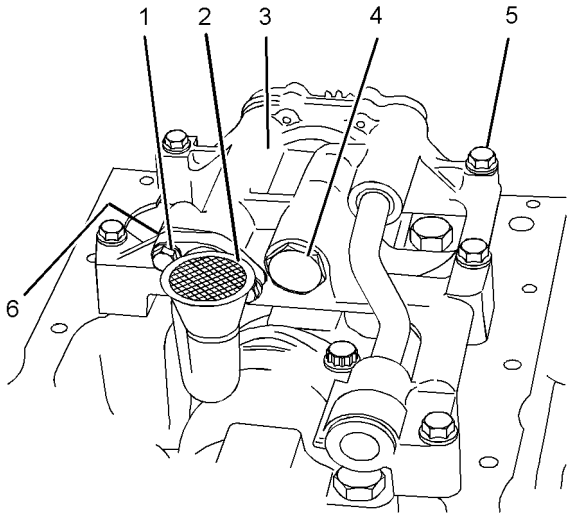


Illustration 54

g01381984

Typical example

1. If necessary, remove the suction pipe . Remove bolts (1) and suction pipe (2).
2. Remove joint (6) (not shown).
3. Remove bolts (5). Remove the assembly of engine oil pump (3) from the cylinder block.
4. If necessary, remove pressure relief valve (4) from the housing of engine oil pump (3). Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install".

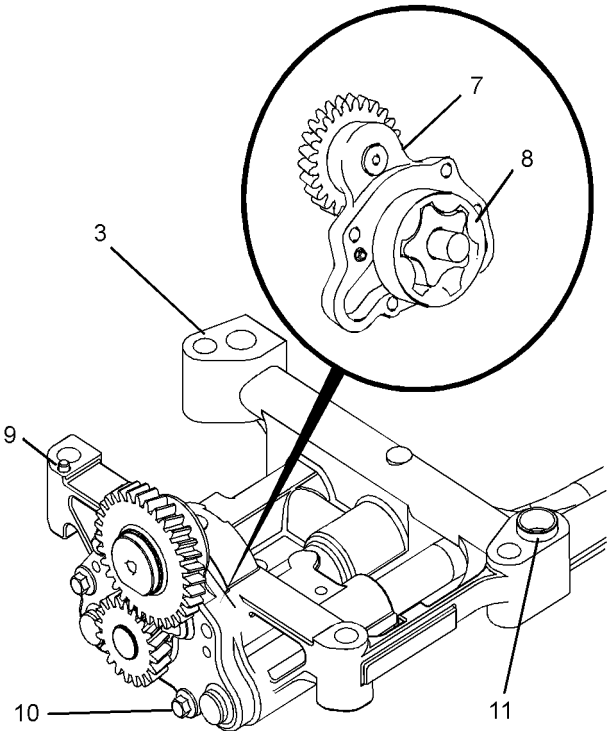


Illustration 55

g01381985

Typical example

5. If necessary, remove bolts (10) and front cover assembly (7). Remove outer rotor (8) from the housing of engine oil pump (3).

Note: Do not remove dowels (9) and (11) from the housing of the engine oil pump unless the dowels are damaged.

Installation Procedure

Table 16

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Magnetic Base	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

If any of the parts on the engine oil pump are worn or damaged, the entire pump must be replaced.

1. Ensure that all components of the engine oil pump are clean and free from wear or damage. Check the clearance between the outer rotor of the oil pump and the oil pump body. Check the clearance between the outer rotor and the inner rotor. Check the end play of the rotor. Refer to Systems Operation, Testing and Adjusting, "Engine Oil Pump - Inspect". Replace the complete assembly of the engine oil pump if any of the components are worn or damaged.

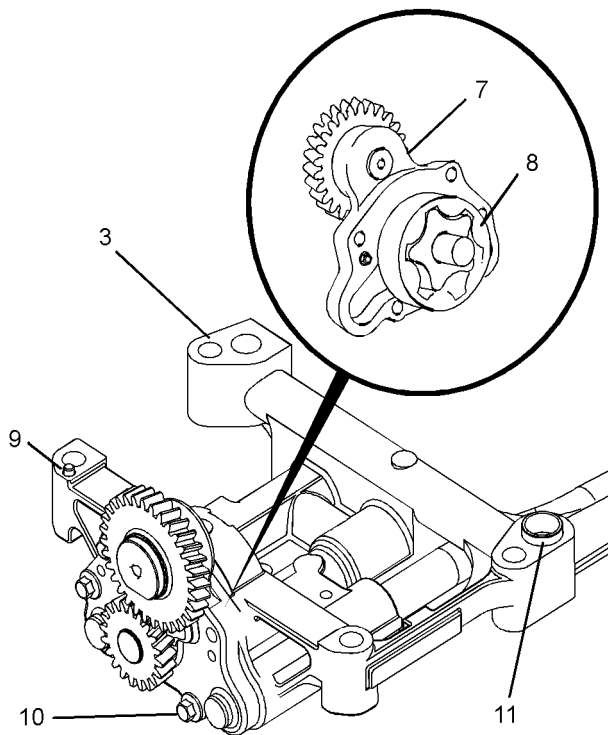


Illustration 56

g01381985

Typical example

2. If necessary, lubricate the internal components of the assembly of the engine oil pump with clean engine oil. Install outer rotor (8) and front cover assembly (7) to the housing of engine oil pump (3). Install bolts (10). Tighten bolts to a torque of 9.5 N·m (84 lb in).

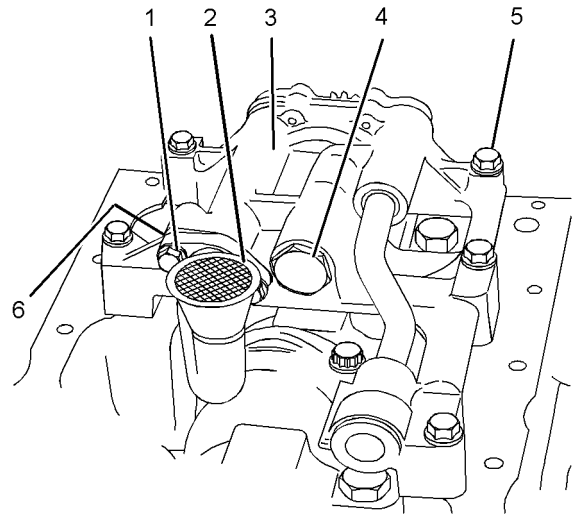


Illustration 57

g01381984

Typical example

3. If necessary, install pressure relief valve (4). Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install" for further information.

4. Ensure that dowels (9) and (11) are correctly located in the housing of the engine oil pump (3). Position the assembly of the engine oil pump onto the cylinder block.

Note: Ensure that the dowels in the housing of the engine oil pump are aligned with the holes in the cylinder block.

5. Install bolts (5). Tighten bolts (5) to a torque of 44 N·m (32 lb ft).
6. If necessary, install the suction pipe. Install suction pipe (2) and a new joint (6) (not shown) to the assembly of the engine oil pump.
7. Install bolts (1). Tighten bolts (1) to a torque to 22 N·m (16 lb ft).
8. Use Tooling (A) in order to check the backlash between the idler gear of the oil pump and the crankshaft gear. Refer to Specifications, "Gear Group - Front" for further information.

End By:

- a. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

i02746325

Water Pump - Remove

Removal Procedure

Start By:

- a. Remove the fan and the fan pulley. Refer to Disassembly and Assembly, "Fan - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Loosen the hose clamps and remove the hose from the water pump inlet.

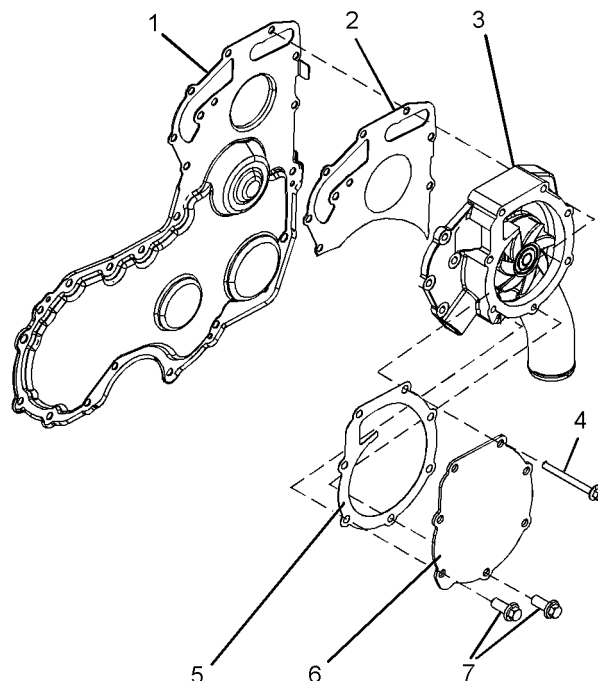


Illustration 58

g01263054

Typical example

3. Remove bolts (4). The bolts are different lengths. Note the positions of the different bolts.

Note: Do not remove bolts (7) at this time.

4. Remove water pump (3) from front cover (1).

Note: If necessary, tap the water pump with a soft hammer in order to loosen the water pump.

5. Remove joint (2).

6. If necessary, remove the cover (6) from the water pump. Follow Steps 6.a through 6.c in order to remove the cover.

- a. Remove bolts (7).

- b. Remove cover (6).

- c. Remove joint (5).

i02746326

Water Pump - Install

Installation Procedure

Table 17

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt M8 by 100 mm	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the water pump is clean and free from wear or damage. If necessary, replace the water pump.

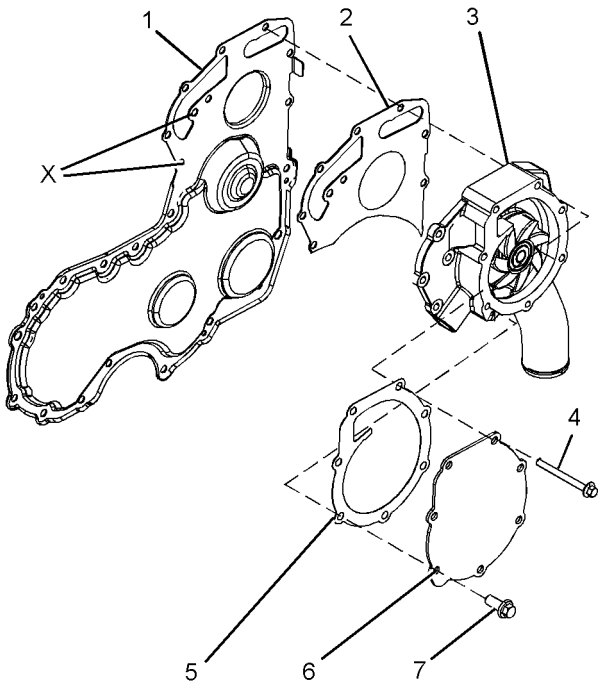


Illustration 59

g01269391

Typical example

2. If necessary, install cover (6) to water pump (3). Follow Steps 2.a through 2.d in order to install the cover.

- a. Clean the mating surface of cover (6).
- b. Position a new joint (5) onto water pump (3).
- c. Install cover (6) to water pump (3).
- d. Install bolts (7) to cover (6). Tighten the bolts finger tight.

3. Clean the mating surface of front cover (1).

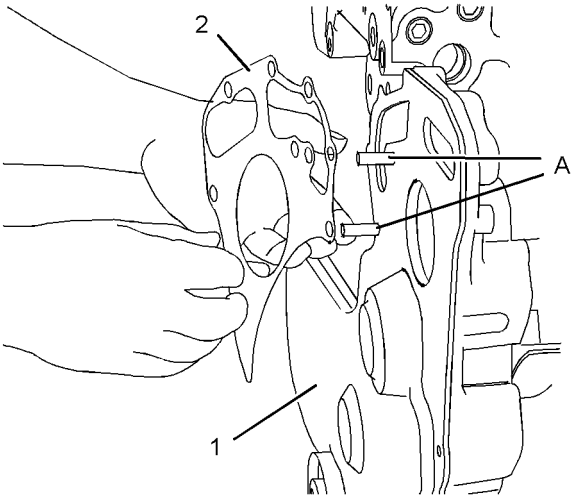


Illustration 60

g01269392

4. Install Tooling (A) in Position (X).
5. Use Tooling (A) in order to align a new joint (2) to front cover (1). Install the joint to the front cover.
6. Align water pump (3) with Tooling (A). Install the water pump to front cover (1).

Note: Ensure that the gear of the water pump and the gear of the fuel injection pump mesh.

7. Install bolts (4). Refer to Illustration 59. Tighten the bolts finger tight.

Note: Ensure that bolts of different lengths are installed in the correct positions.

8. Remove Tooling (A) and install remaining bolts (4) finger tight.

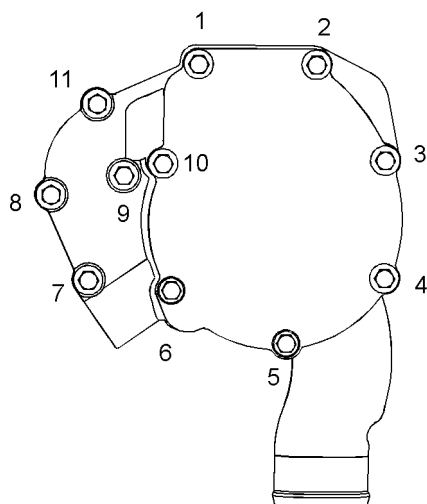


Illustration 61

g01269393

Tightening sequence for the water pump

9. Tighten bolts (4) and bolts (7) to a torque of 22 N·m (16 lb ft). Tighten the bolts in the sequence that is shown in Illustration 61.
10. Install the hose to the water pump inlet. Tighten the hose clamps.
11. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

End By:

- a. Install the fan and the fan pulley. Refer to Disassembly and Assembly, "Fan - Remove and Install".

i02746327

Water Temperature Regulator - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system to a level below the water temperature regulator, into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.
2. Loosen the hose clamps from the upper radiator hose and disconnect the upper radiator hose from water temperature regulator housing (2).

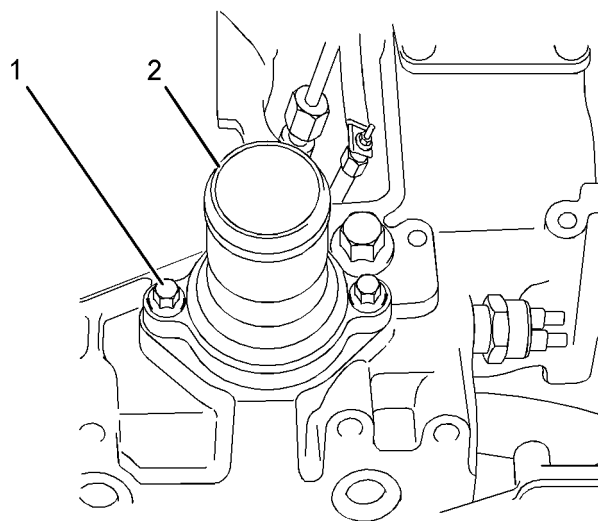


Illustration 62

g01343959

Typical example

3. Remove bolts (1) from water temperature regulator housing (2).
4. Remove water temperature regulator housing (2) from the cylinder head.

Note: Note the orientation of the water temperature regulator housing.

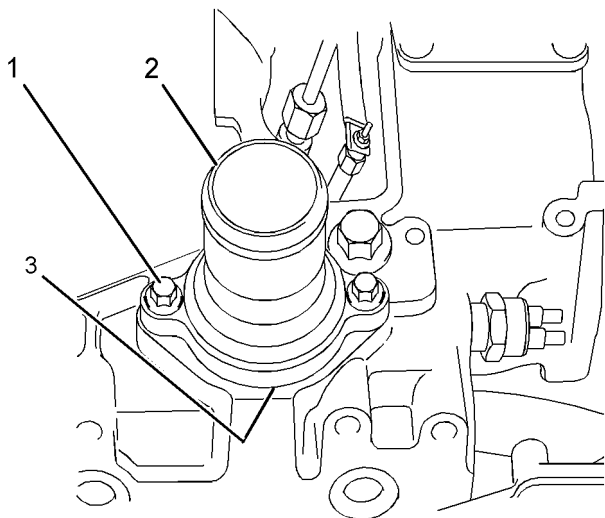


Illustration 63
Typical example

5. Remove O-ring seal (3) (not shown) from water temperature regulator housing (2).

Installation Procedure

Table 18

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of water temperature regulator are clean and free of wear or damage. Check the water temperature regulator for correct operation. Refer to Systems Operation, Testing and Adjusting, "Water Temperature Regulator - Test" for the procedure to test the water temperature regulator. If any components of the water temperature regulator are worn or damaged, the complete assembly must be replaced.
2. The bore in the cylinder head for the water temperature regulator should be clean and free from damage.

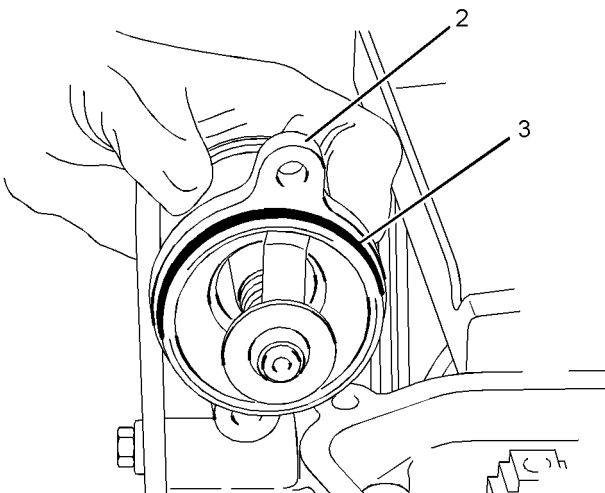


Illustration 64
Typical example

3. If the original water temperature regulator housing is installed, position a new O-ring seal (3) into the groove in water temperature regulator housing (2).

A new water temperature regulator housing is supplied with a new O-ring seal.

4. Use Tooling (A) to lubricate the new O-ring seal.
5. Install water temperature regulator housing (2) to the cylinder head.

Note: Ensure the correct orientation of the water temperature regulator housing.

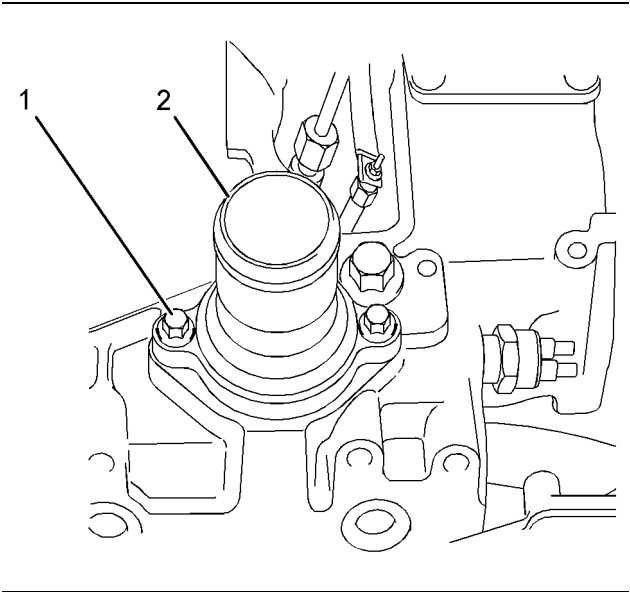


Illustration 65
Typical example

- 6. Install bolts (1). Tighten the bolts to a torque of 22 N·m (16 lb ft).
- 7. Connect the upper radiator hose and tighten the hose clamps.
- 8. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

i02746328

Flywheel - Remove

Removal Procedure

Table 19

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt 1/2 inch - UNF by 4 inch	2

Start By:

- a. Remove the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

NOTICE
Keep all parts clean from contaminants.
Contaminants may cause rapid wear and shortened component life.

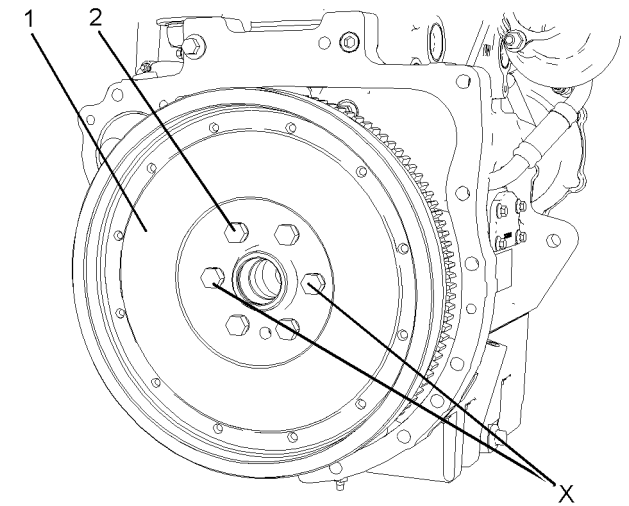


Illustration 66
Typical example

- 1. Remove two bolts from Positions (X) on flywheel (1).
- 2. Install Tooling (A) to Positions (X) on flywheel (1).
- 3. Attach a suitable lifting device to flywheel (1). Support the weight of flywheel (1). The weight of flywheel (1) is approximately 71 kg (155 lb).
- 4. Remove remaining bolts (2).
- 5. Use the lifting device in order to remove the flywheel from the engine.

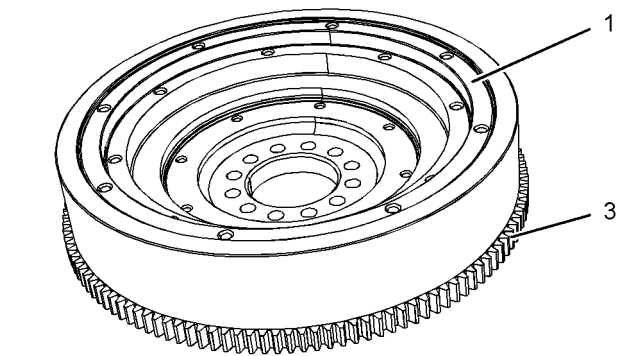


Illustration 67
Typical example

g01245152

6. Inspect flywheel (1) and ring gear (3) for wear or damage. Replace any components that are worn or damaged.
7. To remove the flywheel ring gear, follow Steps 7.a and 7.b.
 - a. Place the flywheel assembly on a suitable support.

Note: Identify the orientation of the teeth on the flywheel ring gear.

- b. Use a hammer and a punch in order to remove ring gear (3) from flywheel (1).

i02746329

Flywheel - Install

Installation Procedure

Table 20

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt 1/2 inch - 20 UNF by 4 inch	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

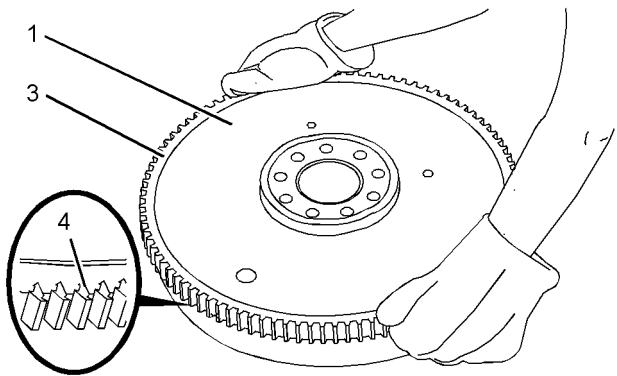


Illustration 68

Typical example

g01343963

WARNING

Always wear protective gloves when handling parts that have been heated.

1. If the flywheel ring gear was removed, follow Steps 1.a through 1.c in order to install a new ring gear to the flywheel.
 - a. Identify the orientation of teeth (4) on the new ring gear (4).

Note: The chamfered side of the ring gear teeth must face toward the starting motor when the flywheel is installed. This will ensure the correct engagement of the starting motor.

- b. Heat flywheel ring gear (3) in an oven to a maximum temperature of 250 °C (482 °F) prior to installation.

Note: Do not use a torch to heat the ring gear.

- c. Ensure that the orientation of ring gear (3) is correct and quickly install the ring gear onto flywheel (1).

2. Inspect the crankshaft rear seal for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".

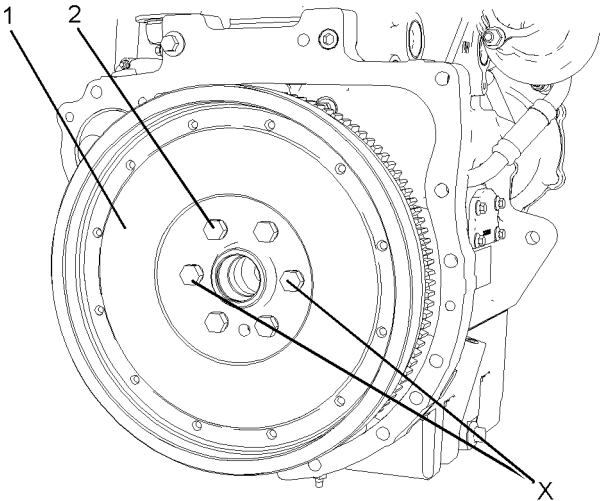


Illustration 69

Typical example

g01401982

3. Install a suitable lifting device to flywheel (1). The weight of flywheel (1) is approximately 71 kg (155 lb).

4. Install Tooling (A) to Positions (X) on the crankshaft.
5. Use the lifting device in order to position flywheel (1) onto Tooling (A).
6. Install bolts (2) to flywheel (1) finger tight.
7. Remove Tooling (A) and install remaining bolts (2) to the flywheel (1).
8. Remove the lifting device from flywheel (1).
9. Use a suitable tool to prevent the flywheel from rotating. Tighten bolts (2) to a torque of 115 N·m (85 lb ft).
10. Check the run out of the flywheel. Refer to System Operation, Test and Adjusting, "Flywheel - Inspect" for further information.

End By:

- a. Install the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

i02746330

Crankshaft Rear Seal - Remove

Removal Procedure

Table 21

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1

Start By:

- a. Remove the flywheel. Refer to Disassembly and Assembly, "Flywheel - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: The crankshaft rear seal and the housing are manufactured as a one-piece assembly. The assembly is not serviceable. If the crankshaft rear seal is removed, the assembly must be replaced.

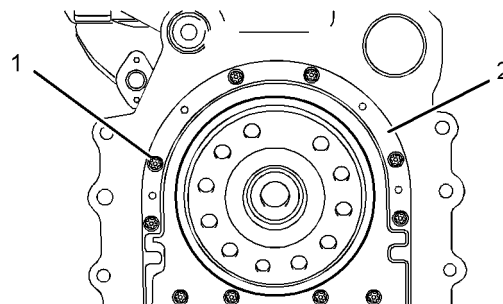


Illustration 70

g01269512

Typical example

1. Use Tooling (A) in order to remove torx screws (1) from crankshaft rear seal (2).
2. Remove crankshaft rear seal (2) from the cylinder block. Discard the crankshaft rear seal.

i02746331

Crankshaft Rear Seal - Install

Installation Procedure

Table 22

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1
B	27610306	Alignment Tool	1

Note: The crankshaft rear seal and the housing are manufactured as a one-piece assembly.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

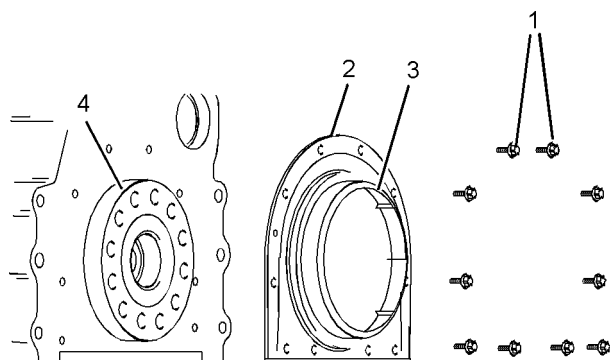


Illustration 71

g01430639

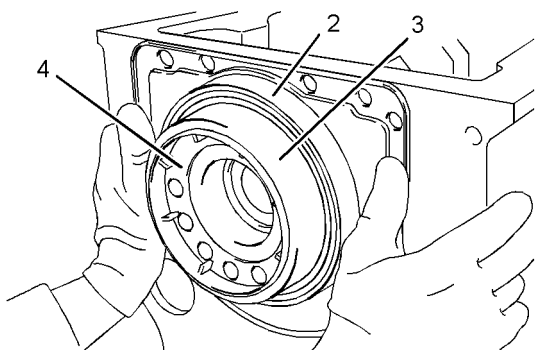


Illustration 72

g01430641

Typical example

1. Ensure that crankshaft flange (4) is clean, dry and free from damage.
2. Ensure that the face of the cylinder block and the bridge piece are clean and dry.
3. A new crankshaft rear seal is supplied with a plastic sleeve (3). Ensure that the plastic sleeve is squarely installed within crankshaft rear seal (2).

Note: The plastic sleeve is included in order to protect the lip of the seal as the seal is pushed over the crankshaft flange.

Note: Do not lubricate the crankshaft rear seal or the crankshaft flange. The crankshaft rear seal must be installed dry.

4. Align plastic sleeve (3) with crankshaft flange (4). Ensure that the plastic sleeve is engaged onto the crankshaft flange. Push new crankshaft rear seal (2) squarely onto the crankshaft flange.

During this process, the plastic sleeve will be forced out of the crankshaft rear seal. Discard the plastic sleeve.

5. Align the two molded locators on crankshaft rear seal (2) with the holes in the cylinder block. Ensure that the crankshaft rear seal is seated against the cylinder block.

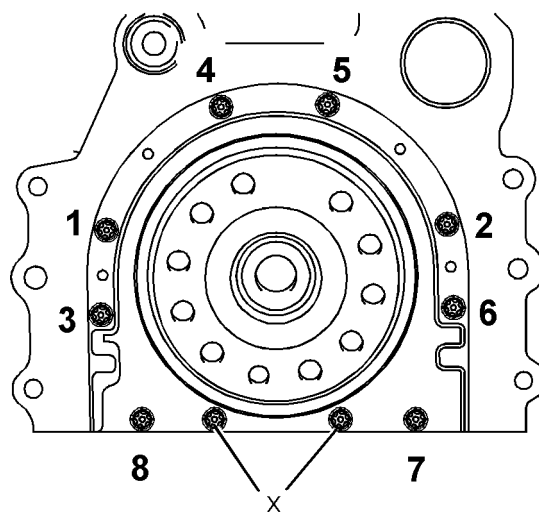


Illustration 73

g01258357

Tightening sequence for the crankshaft rear seal

6. Install torx screws (4) finger tight.

Note: Do not install torx screws to Positions (X) at this stage.

7. Install Tooling (B) to crankshaft rear seal (2) and to crankshaft flange (1).
8. Use Tooling (A) in order to tighten torx screws (4) to a torque of 22 N·m (16 lb ft). Tighten torx screws (4) in the sequence that is shown in Illustration 73.
9. Remove Tooling (B).
10. Install remaining torx screws (4) to Positions (X). Use Tooling (A) in order to tighten the torx screws to a torque of 22 N·m (16 lb ft). Refer to Illustration 73.

End By:

- a. Install the flywheel. Refer to Disassembly and Assembly, "Flywheel - Install".

i02746332

Flywheel Housing - Remove and Install

Removal Procedure

Start By:

- a. Remove the flywheel. Refer to Disassembly and Assembly, "Flywheel - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- 1. Support the rear of the engine.
- 2. Install a suitable lifting device to the flywheel housing in order to support the flywheel housing. The flywheel housing weighs approximately 30 kg (66 lb).

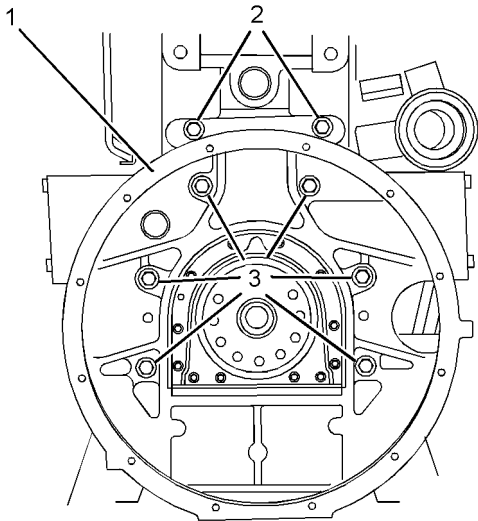


Illustration 74

g01244050

Typical example

- 3. Remove bolts (2) and bolts (3) from flywheel housing (1).
- 4. Use the lifting device in order to remove flywheel housing (1) from the cylinder block. The flywheel housing (1) weighs approximately 30 kg (66 lb).

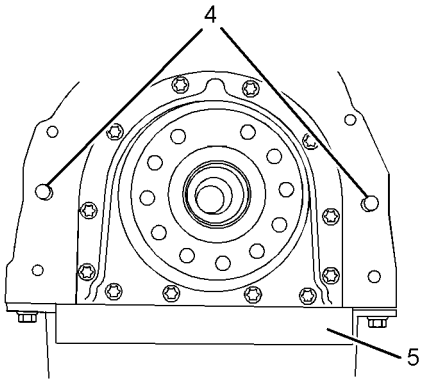


Illustration 75

g01430678

Typical example

- 5. If the engine has an aluminum oil pan, remove dust seal (5).
- 6. If necessary, remove dowels (4) from the cylinder block.

Installation Procedure

Table 23

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud M10 by 100 mm	2
B	21815617	Dial Indicator	1
	-	Magnetic Base	

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- 1. Ensure that the flywheel housing is clean and free from damage. If necessary, replace the flywheel housing.

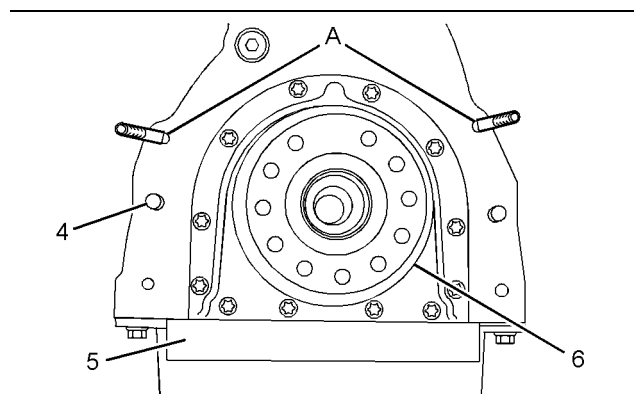


Illustration 76
Typical example

2. Inspect crankshaft rear seal (6) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" and refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install".
3. Clean the rear face of the cylinder block. If necessary, install dowels (4) to the cylinder block.
4. Install Tooling (A) to the cylinder block.
5. Install dust seal (5).

7. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
8. Install bolts (2) and bolts (3) finger tight.
9. Remove Tooling (A). Install the remaining bolts (3).
10. Tighten bolts (3) to a torque of 63 N·m (46 lb ft).
11. Tighten bolts (2) to a torque of 75 N·m (55 lb ft).
12. Use Tooling (B) to check the alignment of the flywheel housing with the crankshaft. Refer to Systems Operation, Testing and Adjusting, "Flywheel Housing - Inspect".

End By:

- a. Install the flywheel. Refer to Disassembly and Assembly, "Flywheel - Install".

i02746333

Crankshaft Pulley - Remove and Install

Removal Procedure

Start By:

- a. Remove the V-Belts. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

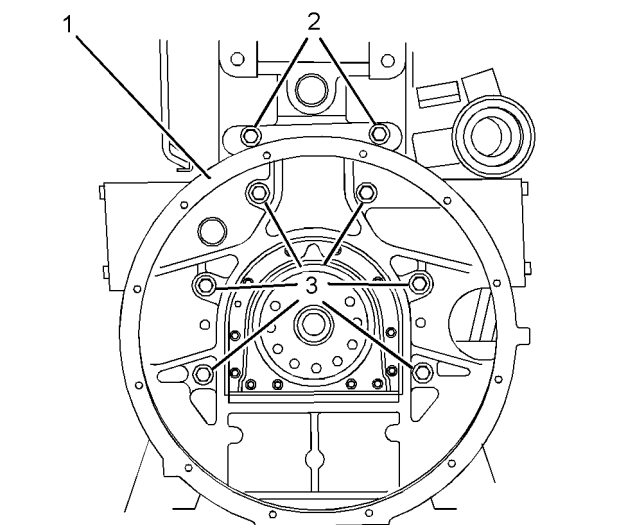


Illustration 77
Typical example

6. Install a suitable lifting device to the flywheel housing. The flywheel housing (1) weighs approximately 30 kg (66 lb).

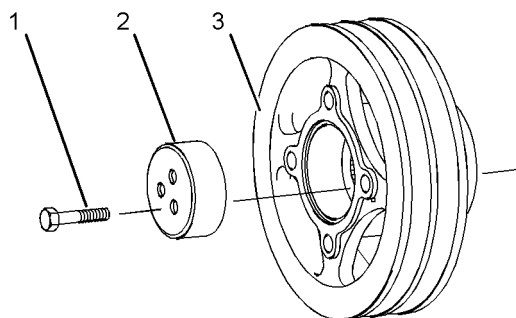


Illustration 78

g01255707

- 1. Use a suitable tool in order to prevent the crankshaft from rotating. Remove bolts (1).
- 2. Remove thrust block (2).
- 3. Carefully remove crankshaft pulley (3) from the crankshaft.

Installation Procedure

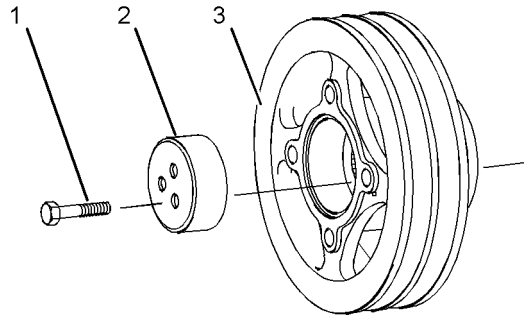


Illustration 79 g01255707

- 1. Ensure that the crankshaft pulley and the thrust block are clean and free from damage. Replace any components that are damaged. It is possible to reclaim a crankshaft pulley with a worn seal surface by installing a wear sleeve. Refer to Disassembly and Assembly, “Crankshaft Wear Sleeve (Front) - Remove and Install”.
- 2. Ensure that the front of the crankshaft is clean and free from damage. Install crankshaft pulley (3) to the crankshaft.

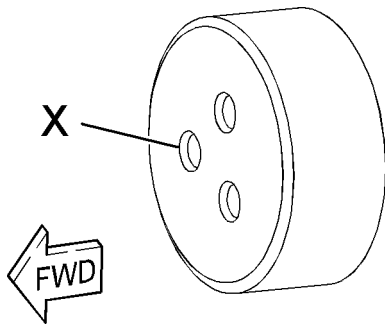


Illustration 80 g01367392

- 3. Align the Holes in thrust block (2) with the holes in the crankshaft.
- Note:** Ensure chamfered Holes (X) in thrust block (2). Face toward the front of the engine.
- 4. Install thrust block (2) to the assembly of the crankshaft pulley.

- 5. Install bolts (1) to thrust block (2).
- 6. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the bolts evenly to a torque of 115 N·m (85 lb ft).
- 7. Repeat Step 6 in order to ensure correct torque.

End By:

- a. Install the V-Belts. Refer to Disassembly and Assembly, “V-Belts - Remove and Install”.

i02746334

Crankshaft Front Seal - Remove and Install

Removal Procedure

Table 24

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610230	Puller	1

Start By:

- a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove and Install”.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

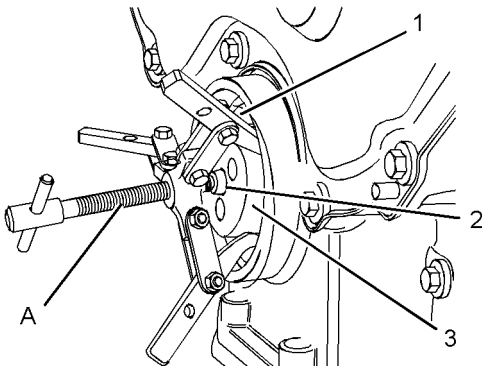


Illustration 81 g01266942

1. Install the legs of Tooling (A) behind crankshaft front seal (1). Install a suitable spacer (2) between Tooling (A) and crankshaft (3). Use Tooling (A) in order to pull the crankshaft front seal out of the front housing.

Note: Do not damage the bore for the crankshaft front seal in the front housing.

Installation Procedure

Table 25

Required Tools			
Tool	Part Number	Part Description	Qty
B	21825577	Threaded Bar	1
	21825580	Anchor Plate	1
	21825579	Sleeve	1
	21825578	Pressure Plate	1
	27610217	Adapter	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the bore for the crankshaft front seal in the front housing is clean and free from damage.

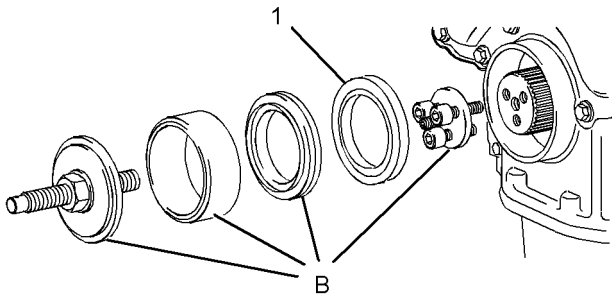


Illustration 82

g01266453

Typical example

2. Assemble Tooling (B).
3. Align a new crankshaft front seal (1) to the front housing.
4. Use Tooling (B) to install crankshaft front seal (1). Ensure that the front face of the seal is installed to a depth of 9.00 ± 0.2 mm (0.354 ± 0.008 inch) into the front housing.

5. Remove Tooling (B) from the crankshaft.

End By:

- a. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".

i02746335

Crankshaft Wear Sleeve (Front) - Remove and Install

Removal Procedure

Start By:

- a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".
- b. Remove the crankshaft front seal . Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Wear sleeves are used to reclaim worn seal surfaces. Wear sleeves are not original equipment. A new crankshaft front seal must be installed when a new wear sleeve is installed.

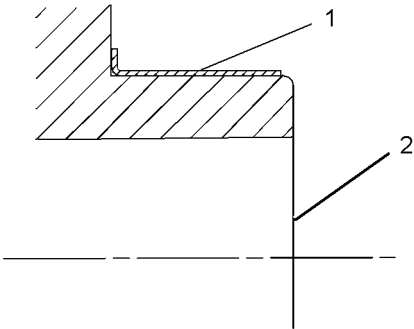


Illustration 83

g01269535

Sectional view of the crankshaft pulley and the wear sleeve

1. Use a sharp tool to score a deep line across wear sleeve (1).

Note: Take care to avoid damaging to the crankshaft pulley.

2. Insert a thin blade between wear sleeve (1) and crankshaft pulley (2) below the scored line. The wear sleeve will separate along the line.
3. Remove wear sleeve (1) from crankshaft pulley (2).

Installation Procedure

Table 26

Required Tools		
Tool	Part Number	Part Description
A	21820518	POWERPART Liquid Gasket

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the crankshaft pulley is thoroughly clean and dry. Remove any areas of raised damage.

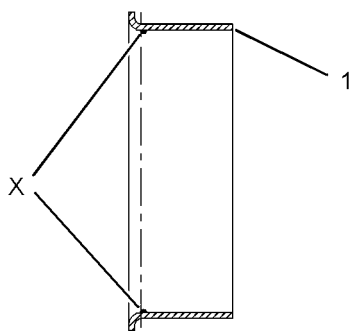


Illustration 84

g01269521

Sectional view of the wear sleeve

2. Apply a small continuous bead of Tooling (A) to the inner surface of wear sleeve (1) at Position X. Apply the bead of Tooling (A) 5.00 mm (0.2 inch) from the flange end of the wear sleeve.

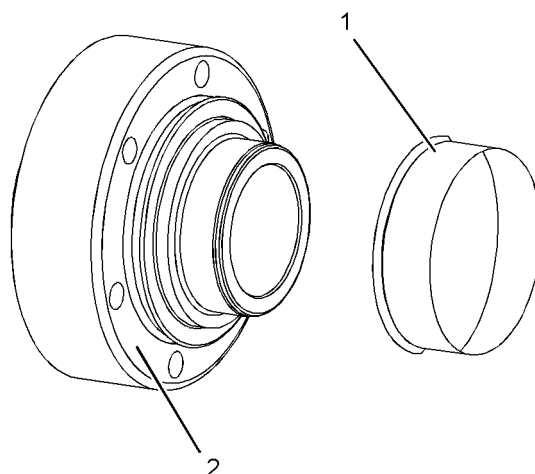


Illustration 85

g01258423

Typical example

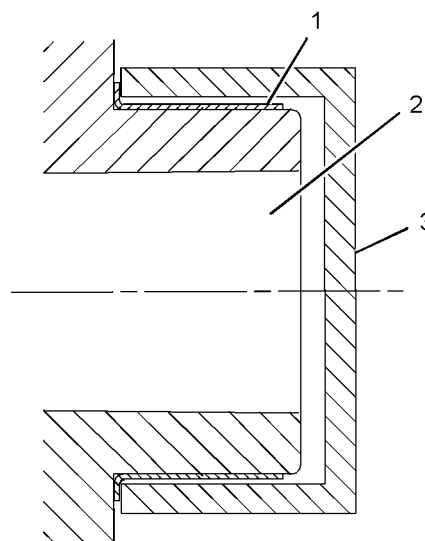


Illustration 86

g01258430

Sectional view of the crankshaft pulley, the wear sleeve and the installation tool

3. Align wear sleeve (1) with crankshaft pulley (2). Use installation tool (3) that is provided with the wear sleeve and use a suitable press in order to install wear sleeve (1) onto crankshaft pulley (2).

Note: Ensure that the wear sleeve is installed squarely against the shoulder of the crankshaft pulley.

4. Remove installation tool (3) from wear sleeve (1).
5. Ensure that wear sleeve (1) has no rough edges.

End By:

- a. Install a new crankshaft front seal. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install".
- b. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".

i02746302

Front Cover - Remove and Install

Removal Procedure

Start By:

- a. If the engine is equipped with a fan, remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".
- b. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove".

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: In order to remove the front cover, it is not necessary to remove the crankshaft pulley or the alternator.

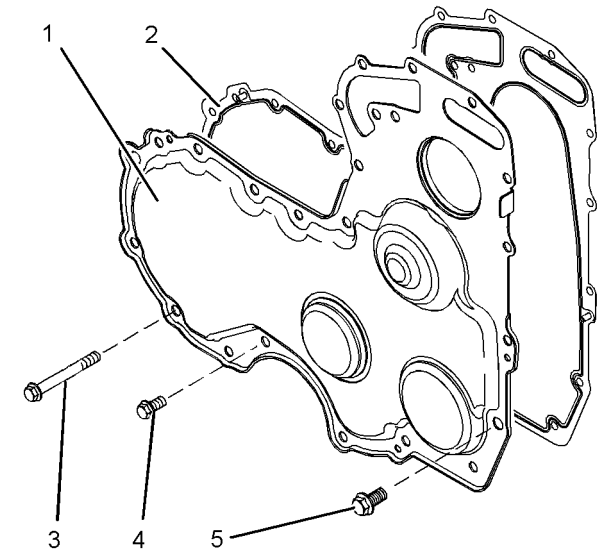


Illustration 87

g01258462

Typical example

- 1. If the engine is equipped with a cylinder block mounted fan drive. Remove fan drive from the cylinder block. Refer to Disassembly and Assembly, "Fan Drive- Remove and Install".
- 2. Remove bolts (3), (4), and (5). Identify the positions of the different bolts.
- 3. Remove front cover (1) from the front housing.
- 4. Remove joint (2) from front cover (1).

Installation Procedure

Table 27

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Guide Bolt M8 by 100 mm	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

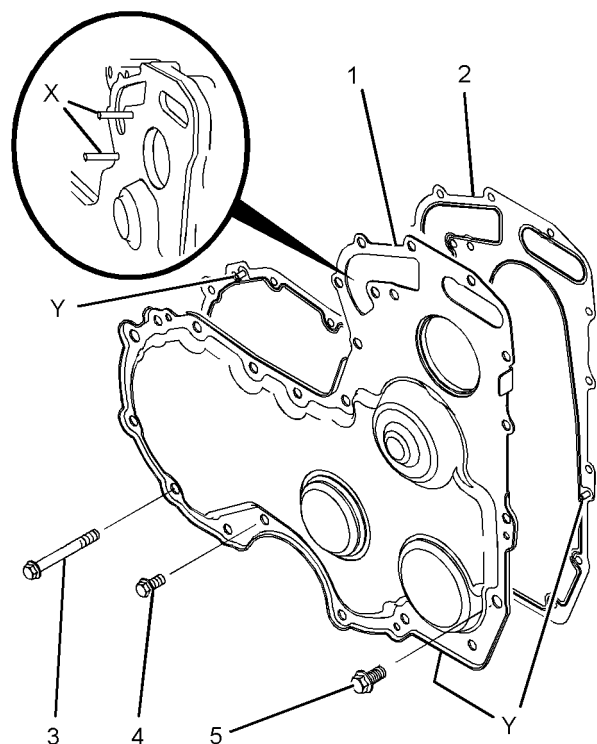


Illustration 88

g01343967

Typical example

1. Thoroughly clean the mating surface of the front housing.
2. If the original front cover is installed, follow Steps 2.a and 2.b in order to install the joint.
 - a. Thoroughly clean the front cover.
 - b. Install a new joint (2) to front cover (1). Engage Locators (Y) into the holes in the front cover.
3. Install Tooling (A) into Holes (X) in the front housing.
4. Use Tooling (A) in order to position the front cover assembly onto the front housing.
5. Install bolts (3), (4), and (5) finger tight. Ensure that the different bolts are installed in the correct positions.
6. Loosely install the water pump assembly and remove Tooling (A). Refer to Disassembly and Assembly, "Water Pump - Install" for the correct procedure.
7. Tighten bolts (3), (4), and (5) to a torque of 22 N·m (16 lb ft).
8. Tighten the bolts for the water pump to a torque of 22 N·m (16 lb ft).
9. If the engine was equipped with a cylinder block mounted fan drive. Install the fan drive to the cylinder block. Refer to Disassembly and Assembly, "Fan Drive- Remove and Install".

End By:

- a. If the engine is equipped with a fan, install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

i02746339

Gear Group (Front) - Remove and Install**Removal Procedure**

Table 28

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	27610211	Timing Pin (Crankshaft)	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. If the engine is equipped with an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove".
- b. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
- c. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the front gear group. Carefully follow the procedure in order to remove the gear group.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

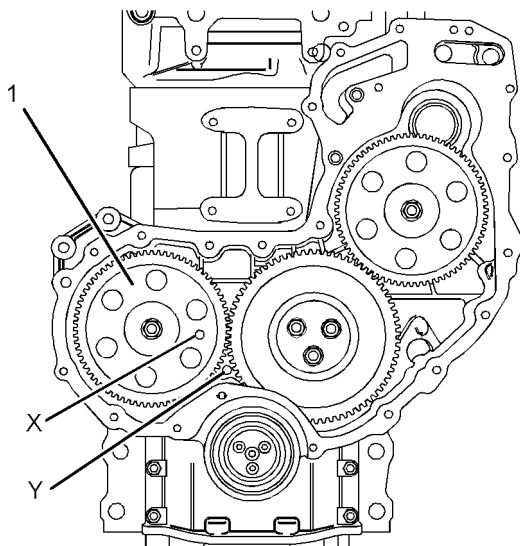


Illustration 89
Typical example

2. Install Tooling (B) through Hole (X) in camshaft gear (1) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position. Install Tooling (C) into Hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

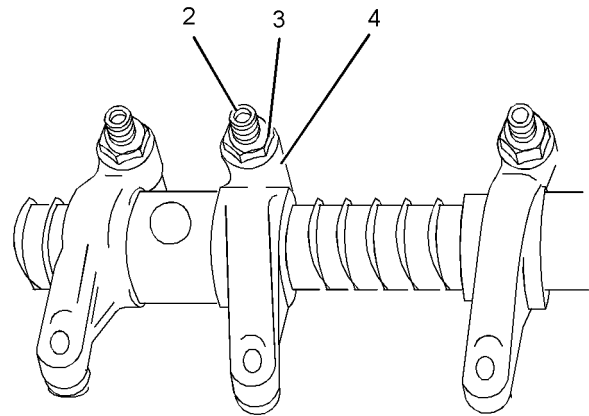


Illustration 90
Typical example

3. Loosen nuts (3) on all rocker arms (4). Unscrew adjusters (2) on all rocker arms (4) until all valves are fully closed.

Note: Failure to ensure that ALL adjusters are fully unscrewed can result in contact between the valves and pistons.

4. Apply sufficient pressure to fuel injection pump gear (6) in a counterclockwise direction in order to remove the backlash. Lock the fuel injection pump in this position. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove" for the correct procedure.

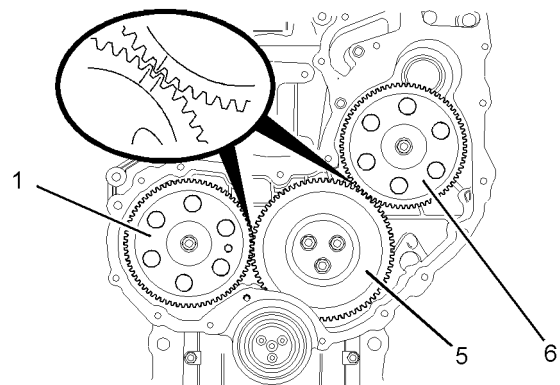


Illustration 91
Typical example

5. Mark gears (1), (5), and (6) in order to show alignment. Refer to Illustration 91.

Note: Identification will ensure that the gears can be installed in the original alignment.

6. Remove fuel pump gear (6). Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove" for the correct procedure.
7. Remove camshaft gear (1). Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".
8. Remove idler gear (5). Refer to Disassembly and Assembly, "Idler Gear - Remove and Install".

Installation Procedure

Table 29

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Timing Pin (Camshaft)	1
C	27610286	Timing Pin (Crankshaft)	1
D	-	Magnetic Base	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The fuel injection pump must remain locked until the procedure instructs you to unlock the fuel injection pump.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

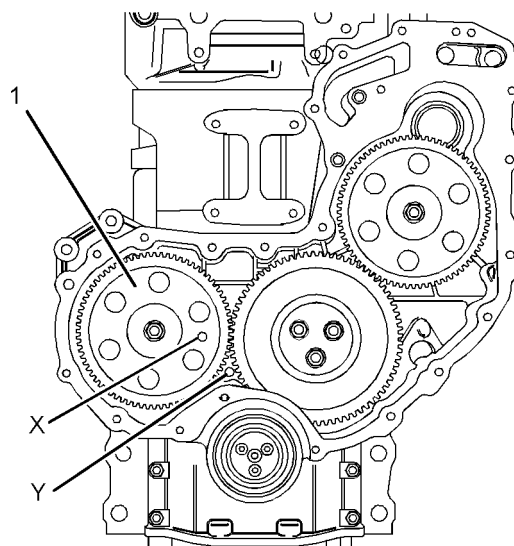


Illustration 92

g01433406

Typical example

2. If necessary, install Tooling (C) into Hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

3. Ensure that all of the components of the front gear group are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.

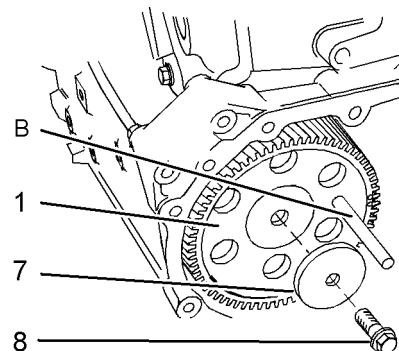


Illustration 93

g01433426

Typical example

4. Install camshaft gear (1). Loosely install bolt (8) and washer (7). Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install" for more information.

5. Install Tooling (B) through Hole (X) in camshaft gear (1) into the front housing.

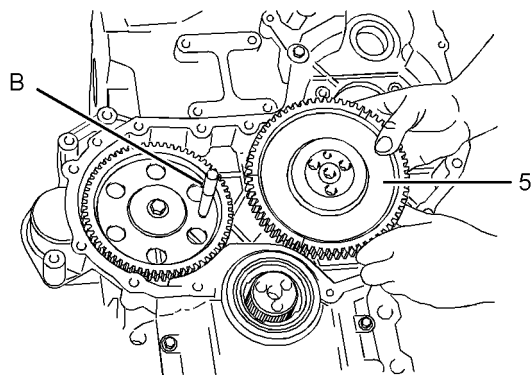


Illustration 94
Typical example

g01433429

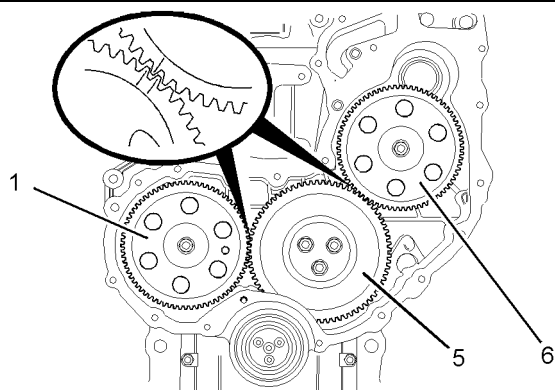


Illustration 95
Alignment of timing marks

g01433418

6. Install idler gear (5). Ensure that the timing marks on gears (1) and (6) are in alignment and that the mesh of the gears is correct. Refer to Disassembly and Assembly, "Idler Gear - Remove and Install". Check the end play of the idler gear. Refer to Specifications, "Gear Group (Front)" and refer to Disassembly and Assembly, "Idler Gear - Remove and Install" for further information.

7. Remove Tooling (B) and Tooling (C). Tighten the bolt for the camshaft gear to a torque of 95 N·m (70 lb ft). Check the end play of the camshaft gear. Refer to Specifications, "Camshaft" for more information.

Install Tooling (B) through Hole (X) in camshaft gear (1) into the front housing and install Tooling (C) into Hole (Y) in the front housing.

8. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install".

9. Install fuel injection pump gear (6). Refer to Disassembly and Assembly, "Fuel Injection Pump Gear - Install" for the correct procedure. Ensure that timing marks on gears (5) and (6) are in alignment. See Illustration 95. Ensure that the mesh of the gears is correct.

10. Remove Tooling (B) and Tooling (C).

11. Use Tooling (D) in order to measure the backlash for the gears (1), (5) and (6). Ensure that the backlash for the gears is within specified values. Refer to Specifications, "Gear Group (Front)" for further information.

12. Lubricate each gear with clean engine oil.

13. Adjust the engine valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust".

End By:

- a. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
- b. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
- c. If the engine is equipped with an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Install".

i02746340

Idler Gear - Remove

Removal Procedure (Standard Idler Gear)

Table 30

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610212	Timing Pin (Camshaft)	1
B	27610211	Timing Pin (Crankshaft)	1

Start By:

- a. Remove the crankshaft front pulley. Refer to Disassembly and Assembly, "Crankshaft Front Pulley - Remove and Install".

- b. If the engine is equipped with an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Removal".
- c. Remove the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove".
- d. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that Tooling (A) is installed into Hole (X) in the camshaft gear. Use Tooling (A) in order to lock the camshaft in the correct position.

Note: Ensure that the gears are marked in order to show alignment. Refer to Illustration 97.

2. Ensure that Tooling (B) is installed in Hole (Y) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position.

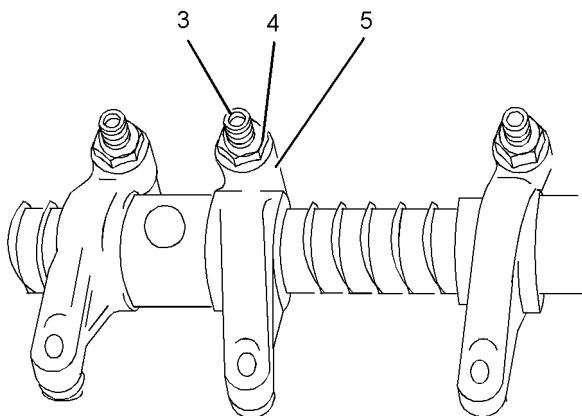


Illustration 96

g01348926

Typical example

3. Loosen nuts (4) on all rocker arms (5). Unscrew adjusters (3) on all rocker arms (5) until all valves are fully closed.

Note: Failure to ensure that ALL adjusters are fully unscrewed can result in contact between the valves and pistons.

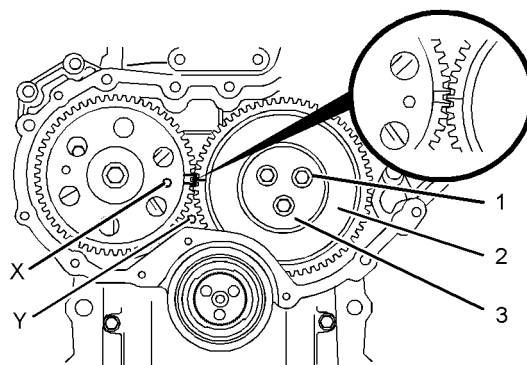


Illustration 97

g01343975

Alignment of timing marks

4. Mark plate (3) in order to show orientation.

Note: Identification will ensure that the plate can be installed in the original orientation.

5. Remove bolts (1). Refer to Illustration 97.

6. Remove plate (3).

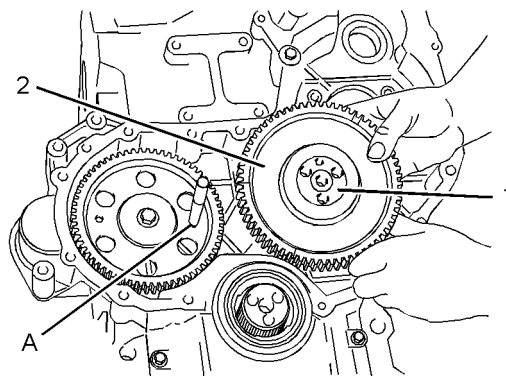


Illustration 98

g01269930

Typical example

7. Remove the assembly of idler gear (2) and hub (7) from the recess in the front housing.

Note: The idler gear must be tilted during removal.

8. Remove hub (7) from idler gear (2).

Removal Procedure (Heavy-Duty Idler Gear)

Table 31

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610212	Timing Pin (Camshaft)	1
B	27610211	Timing Pin (Crankshaft)	1
C	-	Bolt M8x80mm	1

Start By:

- Remove the crankshaft front pulley. Refer to Disassembly and Assembly, "Crankshaft Front Pulley - Remove and Install".
- If the engine is equipped with an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove".
- Remove the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove".
- Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The assembly of heavy-duty idler gear is not serviceable. Do not disassemble the heavy-duty idler gear.

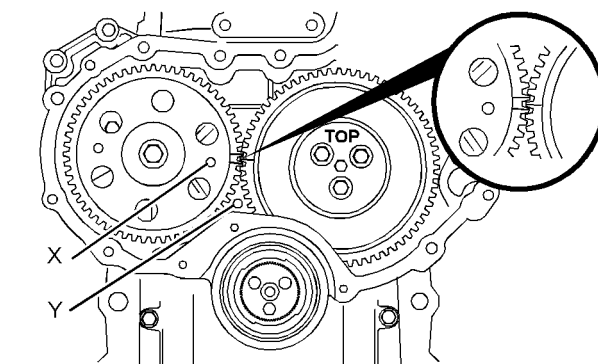


Illustration 99

g01437919

Alignment of timing marks

- Ensure that Tooling (A) is installed into Hole (X) in the camshaft gear. Use Tooling (A) in order to lock the camshaft in the correct position.

Note: Ensure that the gears are marked in order to show alignment. Refer to Illustration 99.

- Ensure that Tooling (B) is installed in Hole (Y) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position.

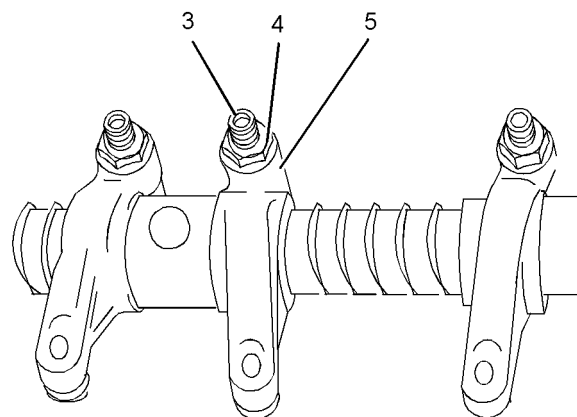


Illustration 100

g01348930

Typical example

- Loosen nuts (4) on all rocker arms (5). Unscrew adjusters (3) on all rocker arms (5) until all valves are fully closed.

Note: Failure to ensure that ALL adjusters are fully unscrewed can result in contact between the valves and pistons.

4. Remove bolts (1) from the assembly of heavy-duty idler gear (2). Refer to Illustration 99.

i02746341

Idler Gear - Install

Installation Procedure (Standard Idler Gear)

Table 32

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610212	Timing Pin (Camshaft)	1
B	27610211	Timing Pin (Crankshaft)	1
C	-	Magnetic Base	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

Illustration 101

g01269933

Typical example

5. Remove the assembly of idler gear (2) from the recess in the front housing.

Note: The idler gear must be tilted during removal.

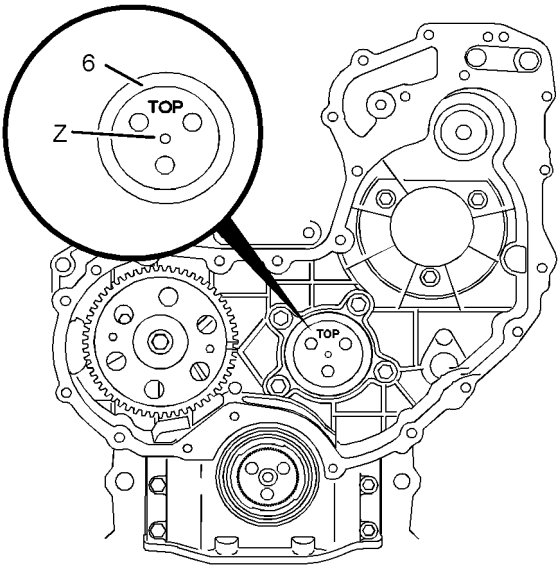


Illustration 102

g01348835

Typical example

6. If necessary, remove plate (6). Install Tooling (C) into threaded Hole (Z) in order to remove plate (6).

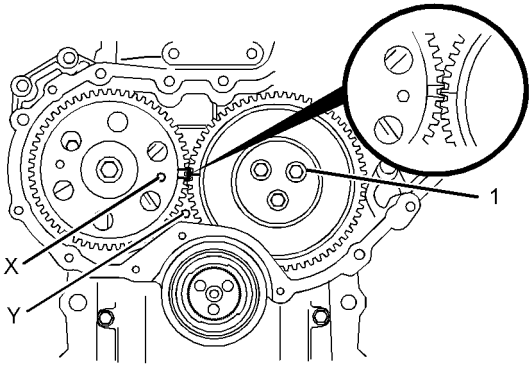


Illustration 103

g01437927

Alignment of timing marks

2. Ensure that Tooling (A) is installed into Hole (X) in camshaft gear (1).
3. Ensure that Tooling (B) is installed in Hole (Y) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

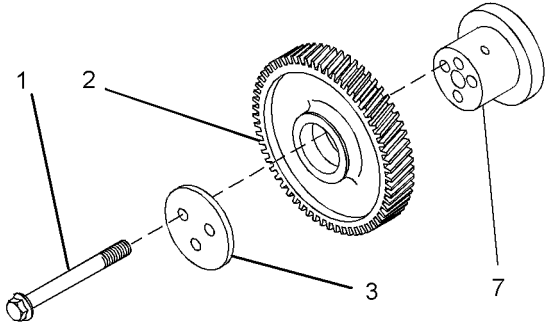


Illustration 104

g01269934

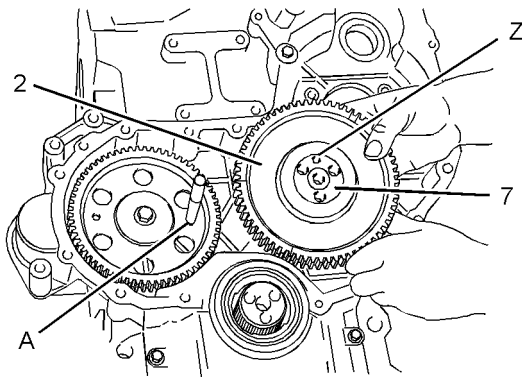


Illustration 105

g01269935

Typical example

4. Clean idler gear (2) and inspect the idler gear for wear or damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the idler gear.
5. Clean hub (7) and inspect the hub for wear or damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the hub.
6. Lubricate hub (7) with clean engine oil. Slide the hub into idler gear (2). Ensure that the timing marks are toward the front of the idler gear.
7. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to the Illustration 103. Install the assembly of idler gear (2) and hub (7) into the recess in the timing case. Ensure that Oil Hole (Z) is to the top of the hub.

Note: The idler gear must be tilted during installation. Ensure that the holes in the hub are aligned with the holes in the cylinder block.

8. Clean plate (3) and inspect the plate for wear or damage. If necessary, replace the plate.

9. Lubricate plate (3) with clean engine oil. A used plate should be installed in the original orientation. If a new plate is installed, ensure that the ground face is toward the idler gear (3). Ensure that the holes in the plate (3) are aligned with the holes in hub (7). Install plate (3) to hub (7).

10. Install bolts (1). Tighten bolts (1) to a torque of 44 N·m (32 lb ft).

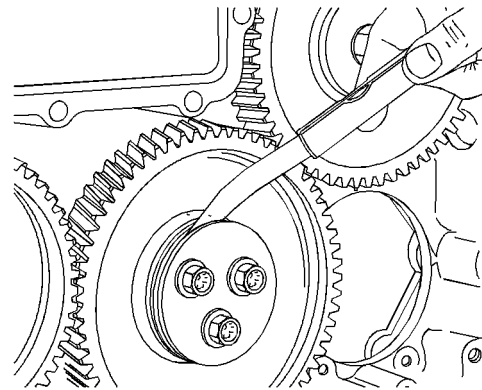


Illustration 106

g01269936

Checking end play by using a set of feeler gauge's

11. Use a set of feeler gauge's in order to check the end play for the idler gear. Refer to Specifications, "Gear Group (Front)" for more information.
12. Use Tooling (C) in order to check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
13. Use Tooling (C) in order to check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
14. Lightly lubricate all of the gears with clean engine oil.

End By:

- a. Install the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Install".
- b. Install the crankshaft front pulley. Refer to Disassembly and Assembly, "Crankshaft Front Pulley - Remove and Install".
- c. If the engine is equipped with an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Install".
- d. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Installation Procedure (Heavy-Duty Idler Gear)

Table 33

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610212	Timing Pin (Camshaft)	1
B	27610211	Timing Pin (Crankshaft)	1
C	-	Magnetic Base	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Postion for No. 1 Piston".

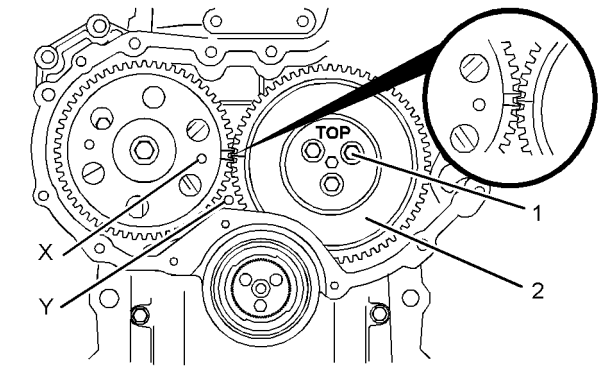


Illustration 107
Alignment of timing Marks

g01343977

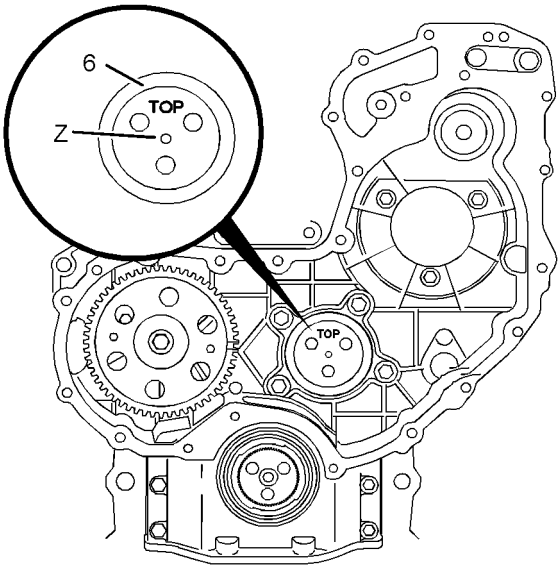


Illustration 108

g01348946

Typical example

2. Ensure that Tooling (A) is installed into Hole (X) in the camshaft gear.
 3. Ensure that Tooling (B) is installed in Hole (Y) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".
 4. Install plate (6) into the recess in the front housing.
- Note:** Ensure that the identification mark TOP is upward.
5. Clean the assembly of idler gear (2) and inspect the assembly of the idler gear for wear or damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the assembly of the idler gear.
 6. Lubricate the bearings in the assembly of idler gear (2) with clean engine oil.

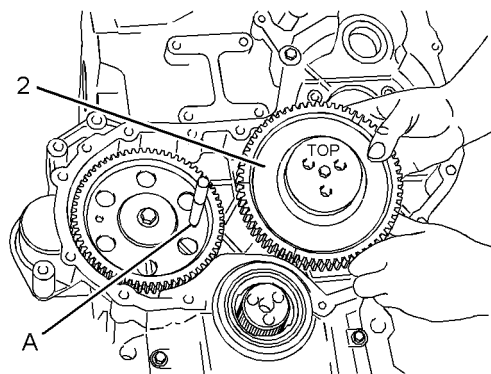


Illustration 109
Typical example

g01438251

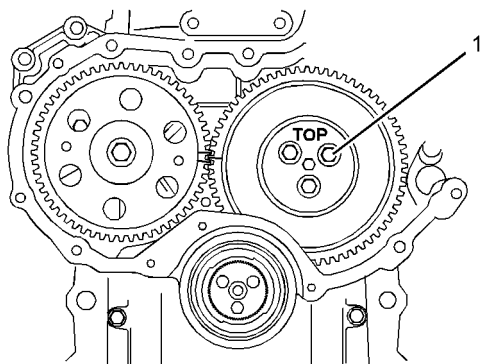


Illustration 110
Typical example

g01438252

7. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to Illustration 107. Install the assembly of idler gear (2) into the recess in the timing case. Ensure that the identification mark TOP is upward.

Note: The idler gear must be tilted during installation. Ensure that the holes in the assembly of the idler gear are aligned with the holes in the cylinder block.

8. Install bolts (1). Tighten bolts (1) to a torque of 44 N·m (32 lb ft).

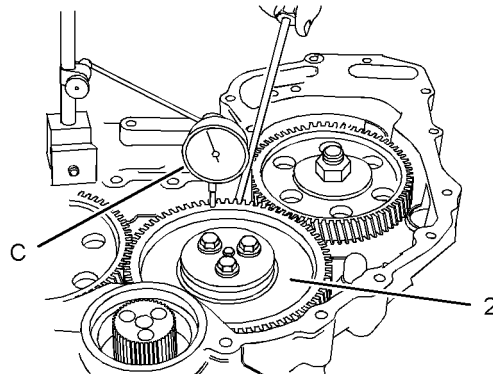


Illustration 111

g01269937

Checking end play by using a dial indicator group

9. Use Tooling (C) in order to check the end play of the idler gear. Refer to Specifications, "Gear Group (Front)" for more information.
10. Use Tooling (C) in order to check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
11. Use Tooling (C) in order to check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
12. Lightly lubricate all of the gears with clean engine oil.

End By:

- a. Install the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Install".
- b. Install the crankshaft front pulley. Refer to Disassembly and Assembly, "Crankshaft Front Pulley - Remove and Install".
- c. If the engine is equipped with an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Install".

i02746342

Housing (Front) - Remove

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".
- b. Remove the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
- c. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".
- d. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".
- e. Remove the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove and Install".
- f. Remove the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

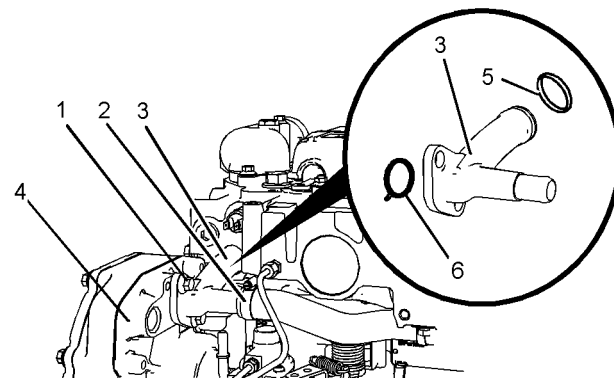


Illustration 112

g01419651

Typical example

1. Loosen hose clamp (2) and remove hose from the bypass tube (3).
2. Remove bolts (1) that secure bypass tube (3) to front housing (4). Remove bypass tube (2). Remove O-ring seal (5) and O-ring seal (6) from bypass tube (3).

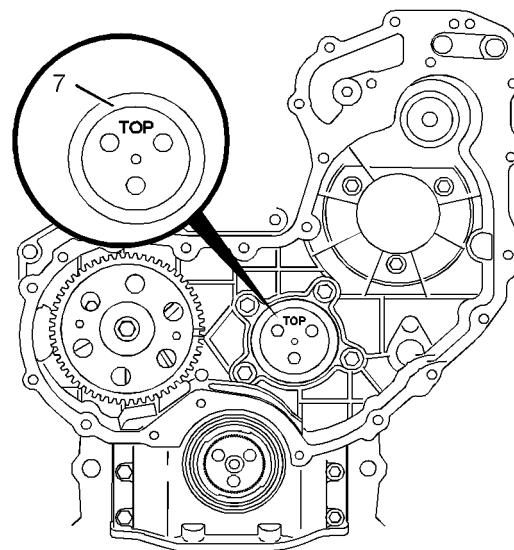


Illustration 113

g01419665

Typical example

3. If the engine is equipped with a heavy duty idle gear. Remove plate (7). Refer to Disassembly and Assembly, "Idle Gear - Remove" for the correct procedure.

i02746343

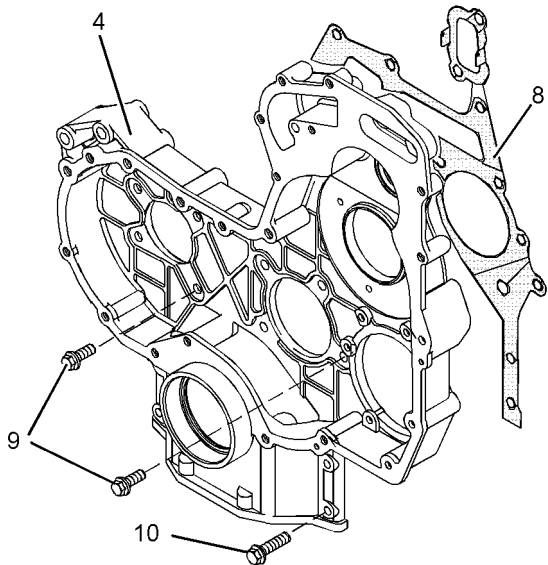


Illustration 114
Typical example

4. Remove bolts (9) and (10) from front housing (4).

Note: The bolts are two different lengths. Note the positions of the different bolts.

5. Remove front housing (4) from the cylinder block.

6. Remove joint (8).

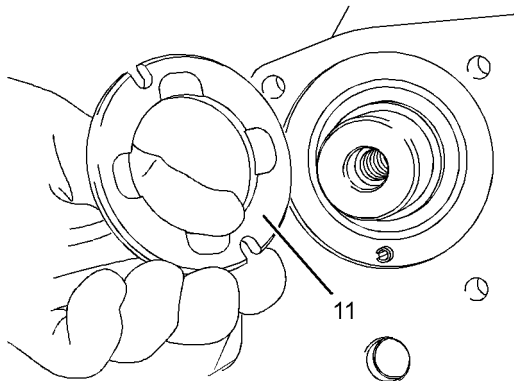


Illustration 115
Typical example

7. Remove thrust washer (11) from the cylinder block.

Housing (Front) - Install

Installation Procedure

Table 34

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	POWERPART Threadlock and Nutlock	1
B	-	Guide Stud (M8 by 80 mm)	2
C	27610216	Alignment Tool	1
	-	Bolts (M10 by 50 mm)	3
D	-	Straight Edge	1
E	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the front housing is clean and free from damage. If necessary, replace the front housing.

If necessary, install blanking plugs to a new front housing. Use Tooling (A) to seal all D-plugs.
2. Check the condition of the crankshaft front seal. If the front seal is damaged, remove the front seal from the front housing.
3. Clean the mating surfaces of the cylinder block.

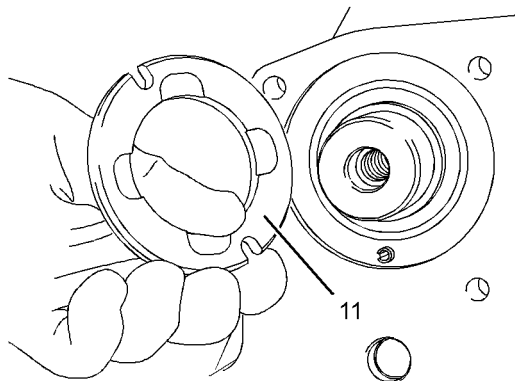


Illustration 116

g01350337

Typical example

4. Install thrust washer (11) into the recess in the cylinder block. Refer to Disassembly and Assembly, "Camshaft - Install" for more information.

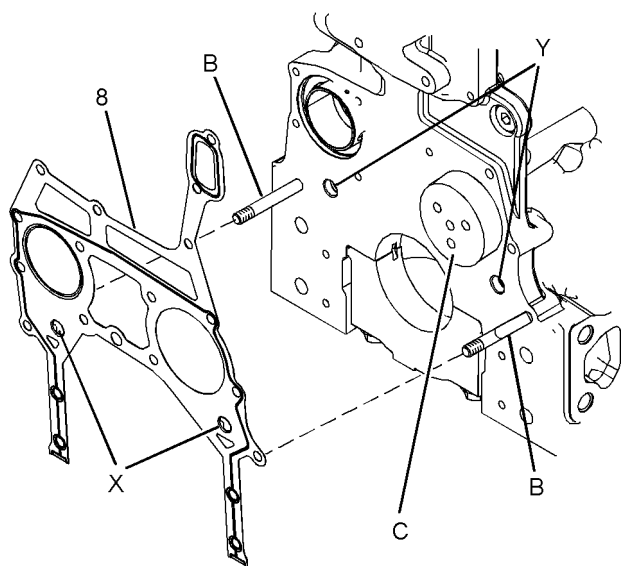


Illustration 117

g01419960

Typical example

5. Install Tooling (B) to the cylinder block.
6. Install Tooling (C) to the cylinder block.
7. Align a new joint (8) with Tooling (B). Install the joint to the cylinder block.

Note: Ensure that Tabs (X) on the joint are engaged in the Holes (Y) in the cylinder block.

8. Install the front housing over Tooling (B) and over Tooling (C) onto the cylinder block.

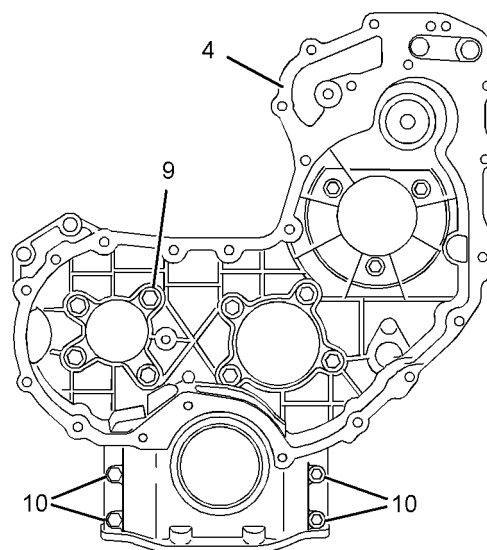


Illustration 118

g01419961

(9) M8 by 20 mm
(10) M8 by 25 mm

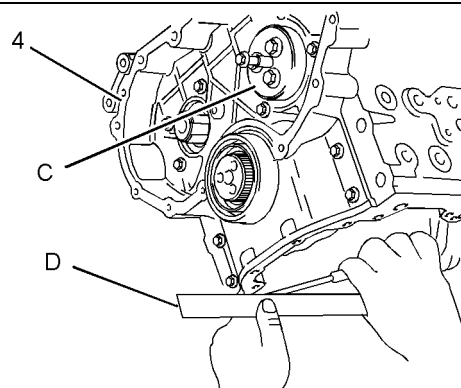


Illustration 119

g01438254

Typical example

9. Install bolts (10) to front housing (4) finger tight.
10. Remove Tooling (B).
11. Install bolts (9).

12. Align the bottom face of front housing (4) to the lower machined face of the cylinder block. Use a Tooling (D) and a feeler gauge in order to check the alignment between the front housing and the cylinder block. Refer to Specifications, "Front Housing and Covers" for further information.

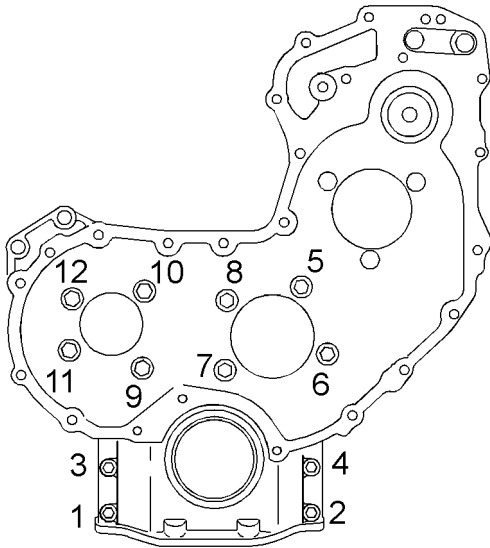


Illustration 120

g01269949

Tightening sequence for the front housing

- 13.** Tighten bolts (9) and (10) to a torque of 28 N·m (20 lb ft).

Note: Ensure that the housing and the cylinder block are correctly aligned.

- 14.** Remove Tooling (C) from the cylinder block.

- 15.** If necessary, install a new crankshaft front seal. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install".

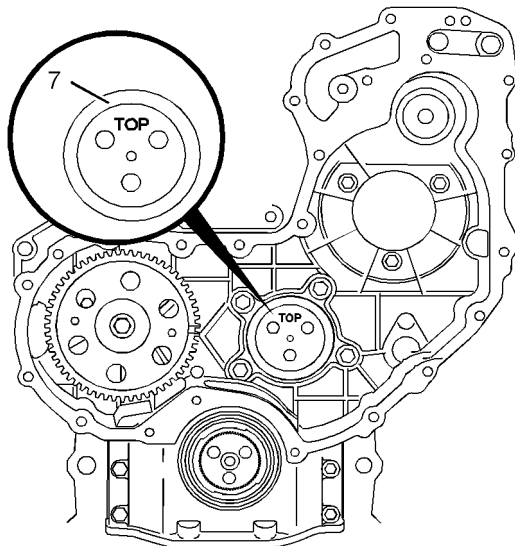


Illustration 121

g01419665

Typical example

- 16.** If the engine is equipped with a heavy duty idle gear. Install plate (7). Refer to Disassembly and Assembly, "Idle Gear - Install" for the correct procedure.

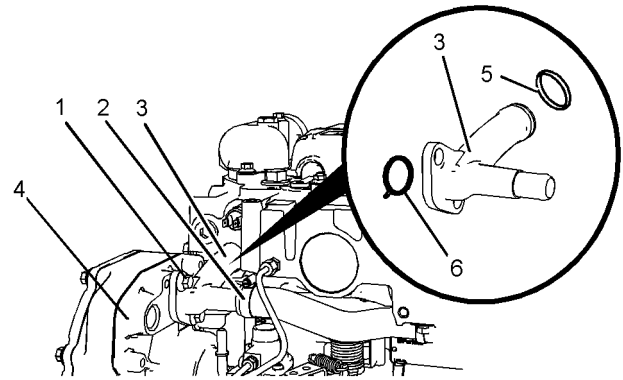


Illustration 122

g01419651

- 17.** Install new O-ring seal (5) and O-ring seal (6) to bypass tube (3). Use Tooling (E) in order to lubricate O-ring seal (5). Install bypass tube (3) to the cylinder head. Install bolts (1). Tighten the bolts to a torque of 22 N·m (16 lb ft).

- 18.** Install hose to bypass tube (3) and securely tighten hose clamp (2).

End By:

- a. Install the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install".
- b. Install the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Install".
- c. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".
- d. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".
- e. Install the alternator. Refer to Disassembly and Assembly, "Alternator - Install".
- f. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

i02911646

Accessory Drive - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

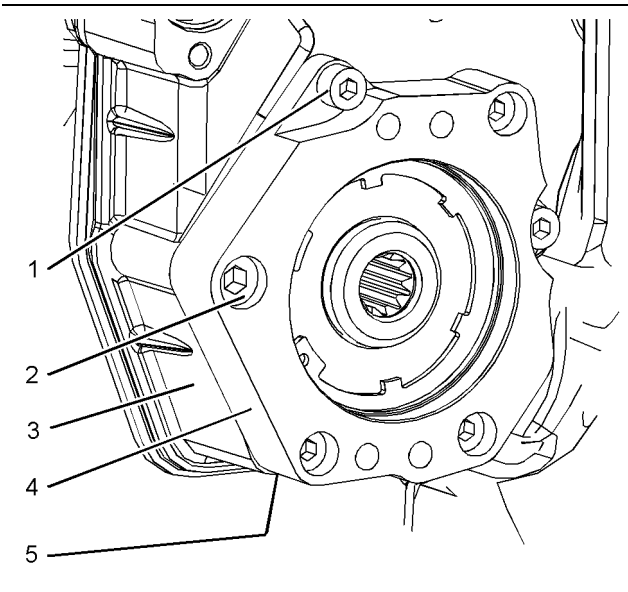


Illustration 123
Typical example

- 1. Remove allen head screw (1) from accessory drive housing (4). Remove allen head screws (2) from accessory drive housing (4).
- 2. Remove accessory drive housing (4) from front housing (3).
- 3. Remove O-ring seal (5) (not shown) from the accessory drive housing (4).

i02911643

Accessory Drive - Disassemble

Disassembly Procedure

Table 35

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Puller	1
	-	Crossblock	1
	-	Puller Leg	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

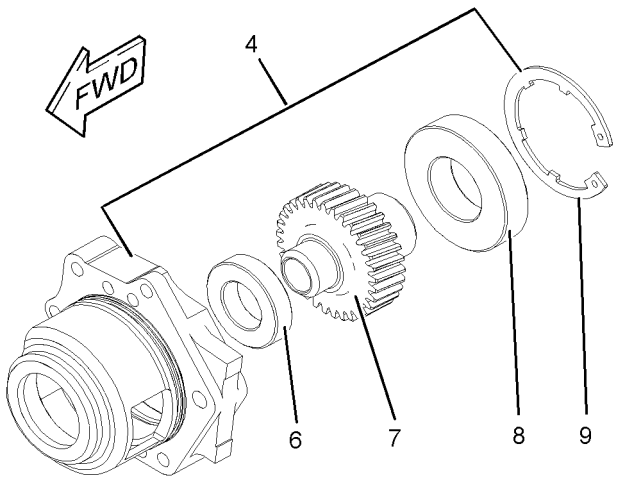


Illustration 124
Typical example

- 1. Remove circlip (9) from accessory drive housing (4).

2. Place accessory drive housing (4) onto a suitable support. Press the assembly of gear (7) and bearing (6) and bearing (8) out of accessory drive housing (4).
3. Use a Tooling (A) in order to remove bearing (6) and bearing (8) from gear (7).

i02911642

Accessory Drive - Assemble

Assembly Procedure

Table 36

Required Tools			
Tool	Part Number	Part Description	Qty
B	21820603	POWERPART Retainer	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

2. Apply a small continuous bead of Tooling (B) to inner Surface (X) of bearing (6). Place the gear shaft on a suitable support. Press on the inner race of bearing (6) until the bearing (6) is against the shoulder of gear (7). Remove any excess sealant.
3. Apply a small continuous bead of Tooling (B) to inner Surface (Z) of bearing (8). Place the inner race of bearing (8) onto a suitable support. Press the shaft of gear (7) onto bearing (8) until the shoulder of the gear is against the bearing. Remove any excess sealant.
4. Apply a small continuous bead of Tooling (B) to the outer Surface (Y) of bearing (6) and bearing (8). Place accessory drive housing (4) on a suitable support. Press the assembly of the gear into the accessory drive housing. Ensure that bearing (6) is against the front face of the recess in accessory drive housing (4). Remove any excess sealant.
5. Install circlip (9) into the groove in accessory drive housing (4). Ensure that circlip (9) is correctly positioned in the groove.

i02911645

Accessory Drive - Install

Installation Procedure

Table 37

Required Tools			
Tool	Part Number	Part Description	Qty
C	21820221	POWERPART Rubber Lubricant	1
D	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

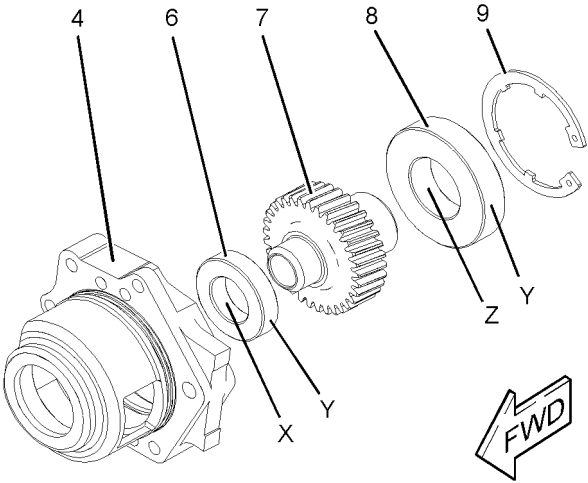


Illustration 125

g01440577

Typical example

1. Inspect the condition of the teeth and the splines of gear (7) for wear or damage. Inspect bearing (6) and bearing (8). Inspect circlip (9), and front housing (4) for wear or damage. Replace any components that are worn or damaged.

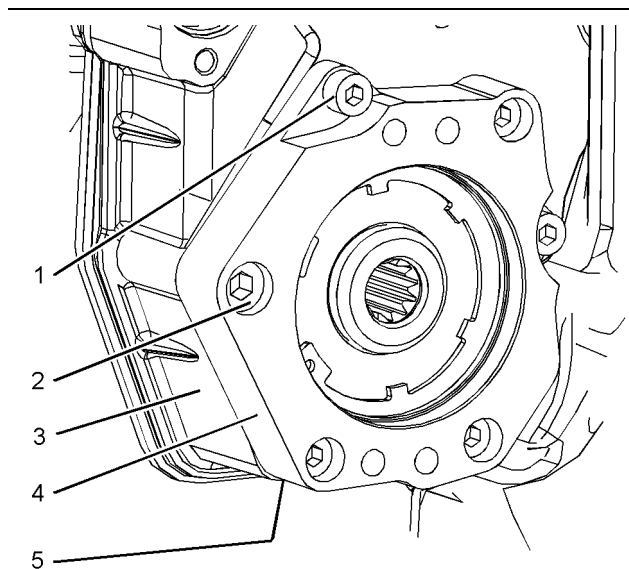


Illustration 126
Typical example

g01441026

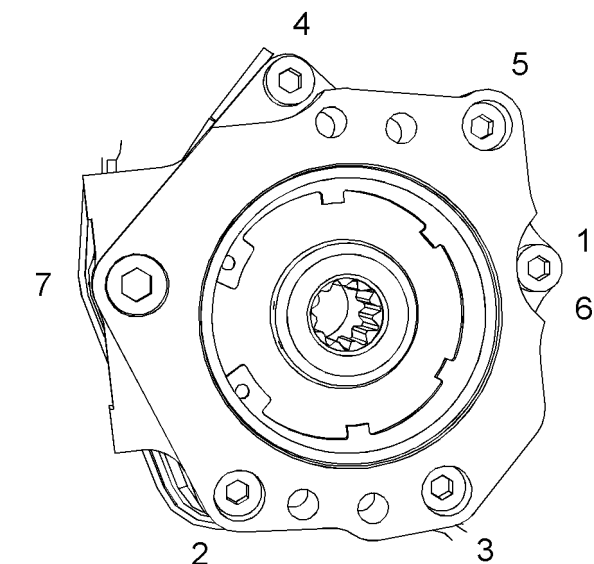


Illustration 127
Sequence for tightening accessory drive

g01444555

1. Inspect the bore in front housing (3) for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" and Disassembly and Assembly, "Housing (Front) - Install".
2. Lightly lubricate a new O-ring seal (5) (not shown) with Tooling (C). Install the O-ring seal (not shown) into the groove in accessory drive housing (4).
3. Lightly lubricate bearing (6), bearing (8), and gear (7) with clean engine lubricating oil. Install the assembly of the accessory drive to the front housing. Ensure that the flange on the accessory drive housing is flush with the front housing.

4. Apply Tooling (D) to allen head screws (1) and allen head screw (2).
5. Install allen head screws (1) and allen head screw (2) to accessory drive housing (4).
6. Tighten allen head screws (1) to a torque of 22 N·m (16 lb ft).

Tighten allen head screw (2) to a torque of 44 N·m (32 lb ft). Tighten allen head screws (1) and (2) in the sequence that is shown in Illustration 127.
7. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

i02746347

Crankcase Breather - Remove and Install (Naturally Aspirated Engines)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

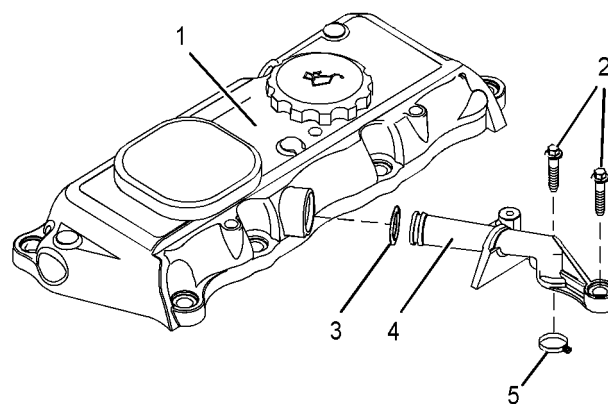


Illustration 128
Typical example

g01382005

1. Remove bolts (2) and remove breather tube (4) from valve mechanism cover (1).
2. Remove O-ring seal (3) and O-ring seal (5) from breather tube (4).

Disassembly Procedure

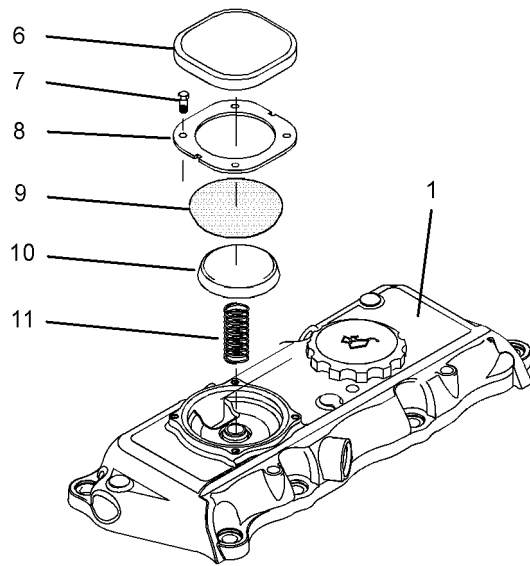


Illustration 129

g01382008

Typical example

WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

1. Remove plastic cover (6) from valve mechanism cover (1).
2. Remove screws (7). Remove plate (8).
3. Remove assembly of diaphragm (9) and the cap (10). Remove spring (11).

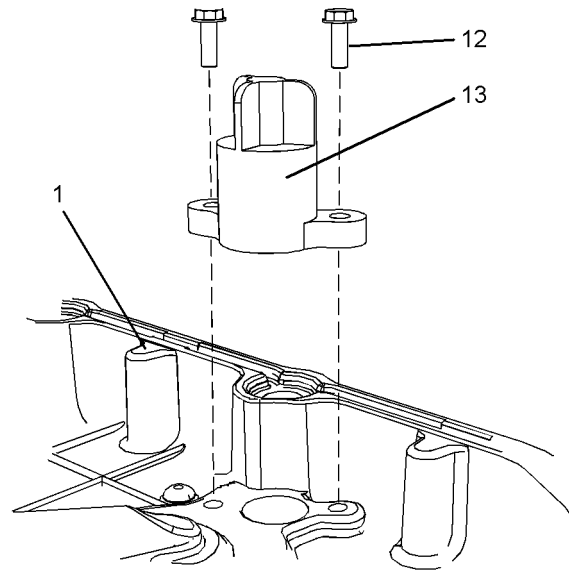


Illustration 130

g01421466

4. If necessary, remove the shut off valve assembly from the valve mechanism cover. Follow Steps 4.a through 4.c in order to remove the shut off valve assembly from the valve mechanism cover.
 - a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
 - b. Remove bolts (12) from shut off valve assembly (13).
 - c. Remove shut off valve assembly (13) from the valve mechanism cover.

Assembly Procedure

Table 38

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610296	Torque Wrench	1

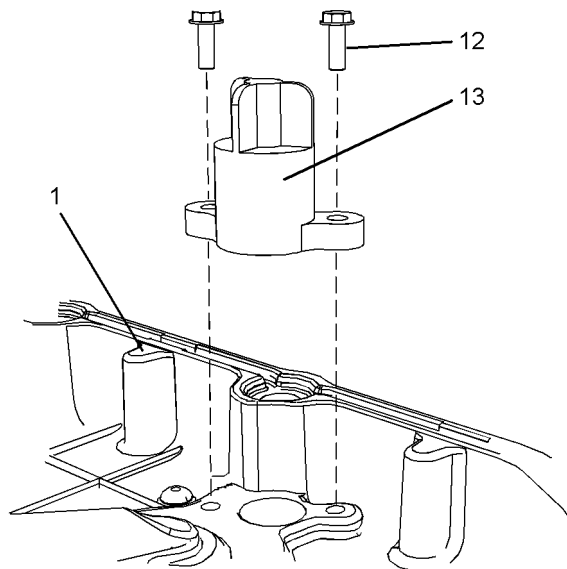


Illustration 131

g01421466

1. If necessary, install shut off valve assembly to the valve mechanism cover. Follow Steps 1.a through 1.f in order to install shut off valve assembly to the valve mechanism cover.
 - a. Ensure that all components of the shut off valve assembly are clean and free from damage. Replace any components that are damaged.
 - b. The ball in shut off valve assembly (13) must be free to move.
 - c. Install shut off valve assembly (13) to the valve mechanism cover.
 - d. Install bolts (12) to shut off valve assembly (13).
 - e. Use Tooling (A) to tighten bolts (12) to a torque of 1.3 N·m (12 lb in).
 - f. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

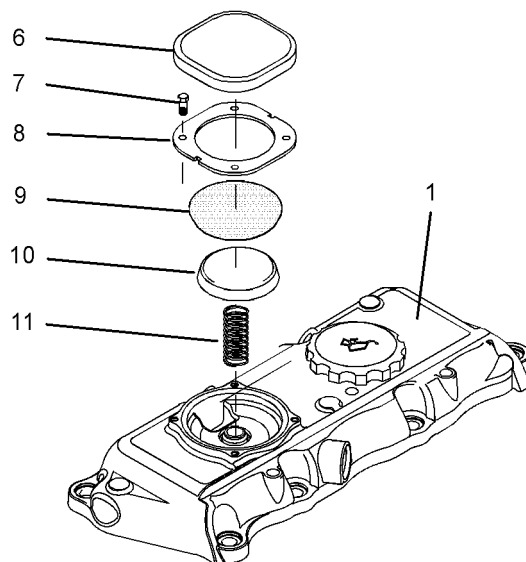


Illustration 132

g01382008

Typical example

WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

2. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.

3. Install spring (11). Install assembly of diaphragm (10) and cap (9).

Note: Ensure that the diaphragm is fully seated into the groove of the valve mechanism cover.

4. Position plate (8) on valve mechanism cover (1) and install screws (7).
5. Use Tooling (A) to tighten screws (7) to a torque of 1.3 N·m (12 lb in).
6. Install plastic cover (6) to valve mechanism cover (1).

Installation Procedure

Table 39

Required Tools			
Tool	Part Number	Part Description	Qty
B	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

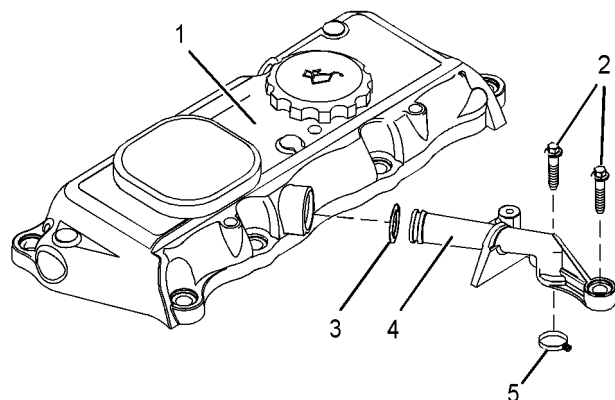


Illustration 133
Typical example

g01382005

1. Install new O-ring seal (3) and O-ring seal (5) to breather tube (4). Use Tooling (B) in order to lubricate the O-ring seal (3).
2. Install breather tube (4) to valve mechanism cover (1). Install bolts (2) and tighten the bolt to a torque of 9 N·m (80 lb in).

Crankcase Breather - Remove and Install (Turbocharged Engines with Unfiltered Breather)

i02746346

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

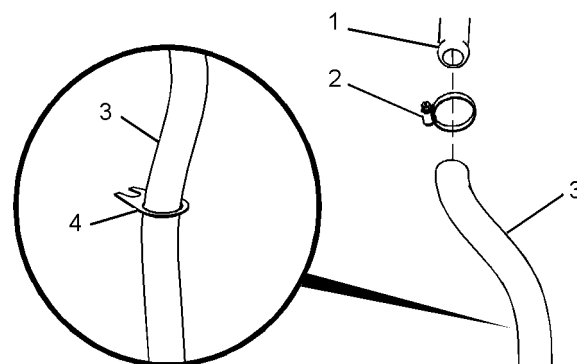


Illustration 134

g01343996

Typical example

1. Loosen clamp (2) and remove hose (3) from breather tube (1). Withdraw hose (3) from clip (4) and remove the hose.

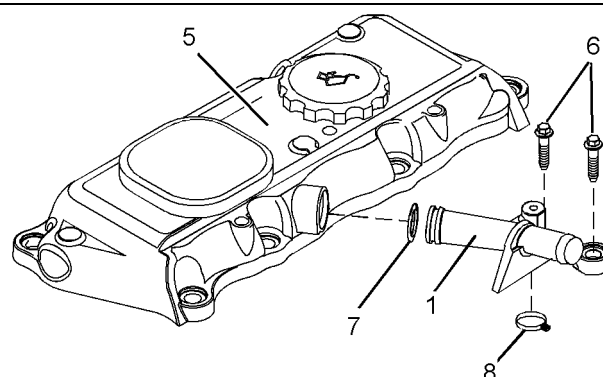


Illustration 135

g01382051

2. Remove bolts (6) and remove breather tube (1) from valve mechanism cover (5).
3. Remove O-ring seal (7) and O-ring seal (8) from breather tube (1).

Disassembly Procedure

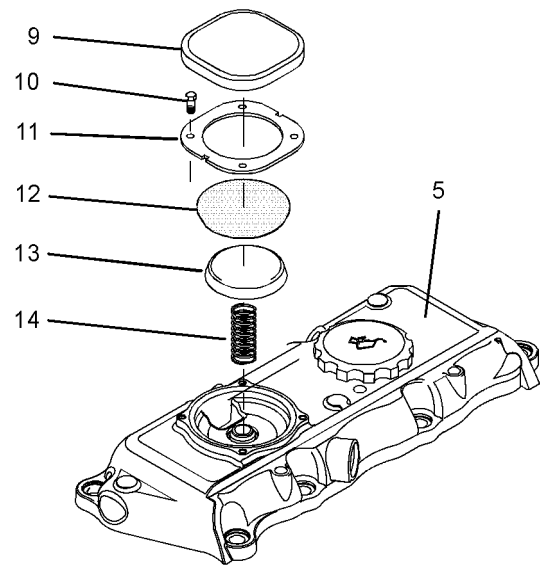


Illustration 136

g01382053

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

1. Remove plastic cover (9) from valve mechanism cover (5).
2. Remove screws (10). Remove plate (11).
3. Remove assembly of diaphragm (12) and the cap (13). Remove spring (14).

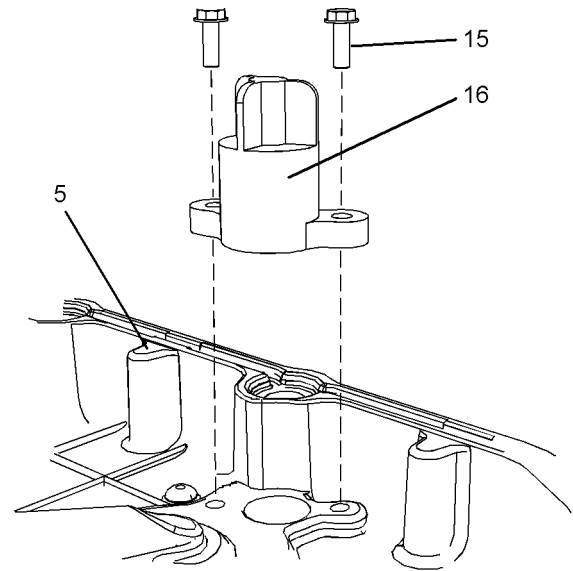


Illustration 137

g01438411

4. If necessary, remove the shut off valve from the valve mechanism cover (5). Follow Steps 4.a through 4.c in order to remove the shut off valve from the valve mechanism cover.
 - a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
 - b. Remove bolts (15) from shut off valve assembly (16).
 - c. Remove shut off valve assembly (16) from the valve mechanism cover (5).

Assembly Procedure

Table 40

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610296	Torque Wrench	1

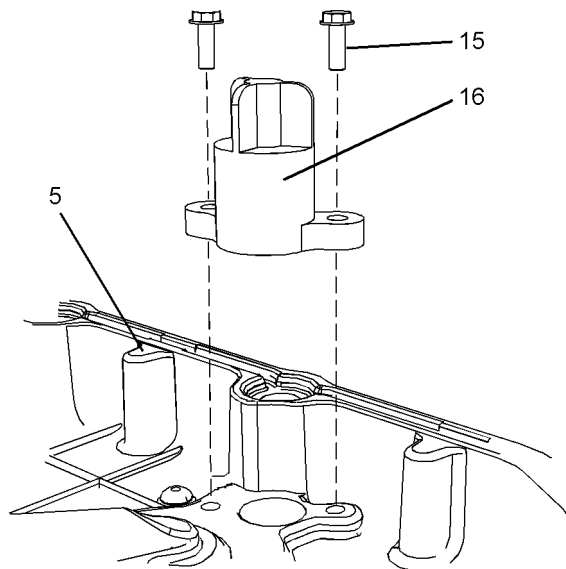


Illustration 138

g01438411

1. If necessary, install shut off valve assembly to the valve mechanism cover (5). Follow Steps 1.a through 1.f in order to install shut off valve assembly to the valve mechanism cover.
 - a. Ensure that all components of the shut off valve assembly are clean and free from damage. Replace any components that are damaged.
 - b. The ball in shut off valve assembly (13) must be free to move.
 - c. Install shut off valve assembly (16) to the valve mechanism cover (5).
 - d. Install bolts (15) to shut off valve assembly (17).
 - e. Use Tooling (A) to tighten bolts (15) to a torque of 1.3 N·m (12 lb in).
 - f. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

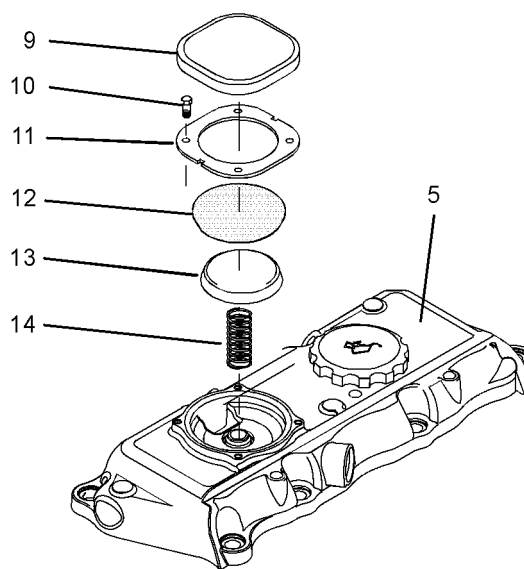


Illustration 139

g01382053

WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

2. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
 3. Install spring (14) to the valve mechanism cover. Install assembly of diaphragm (12) and cap (13).
- Note:** Ensure that the diaphragm is fully seated into the groove of the valve mechanism cover.
4. Position plate (11) on valve mechanism cover (5) and install screws (10).
 5. Use Tooling (A) to tighten screws (10) to a torque of 1.3 N·m (12 lb in).
 6. Install plastic cover (9) to valve mechanism cover (5).

Installation Procedure

Table 41

Required Tools			
Tool	Part Number	Part Description	Qty
B	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

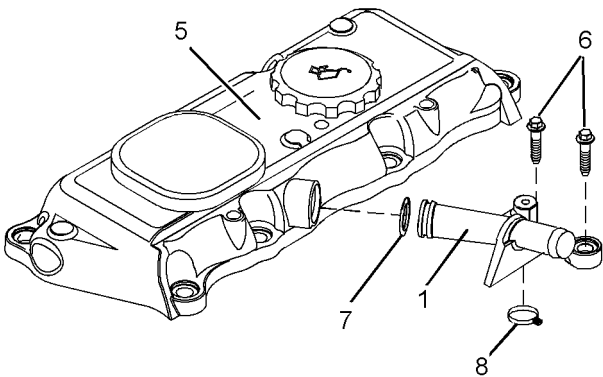


Illustration 140

g01382051

1. Install a new O-ring seal (7) and O-ring seal (8) to breather tube (1). Use Tooling (B) in order to lubricate the O-ring seal (7).
2. Install breather tube (1) to valve mechanism cover (5). Install bolt (6) and tighten the bolt to a torque of 9 N·m (80 lb in).

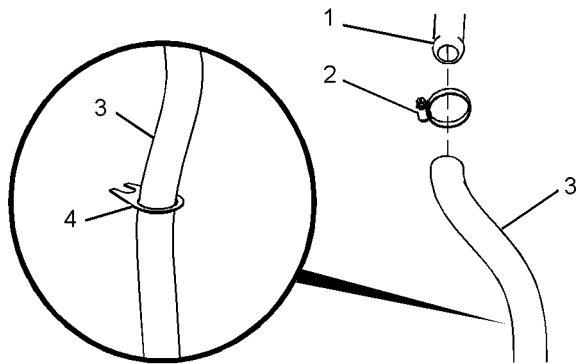


Illustration 141

g01343996

Typical example

3. Connect hose (3) to breather tube (1). Tighten clamp (2). Install hose (3) into clip (4).

Crankcase Breather - Remove and Install
(Turbocharged Engines with Filtered Breather)

i02746345

Removal Procedure

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

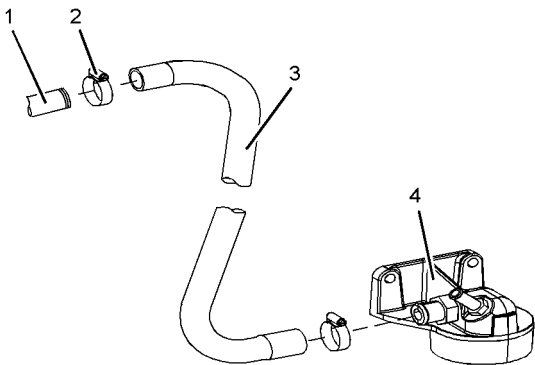


Illustration 142

g01443707

Typical example

1. Release clips (2) in order to remove hose (3). Remove the hose from breather tube (1) and from filter base (4).

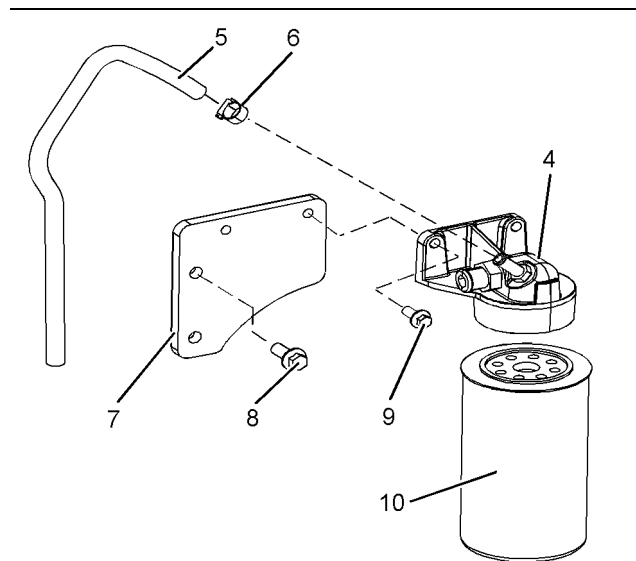


Illustration 143

g01443702

Typical example

2. Remove canister (10). Refer to Operation and Maintenance Manual, "Crankcase Breather (Canister) - Replace".
3. Release clip (6) and remove hose (5) from filter base (4).
4. Remove bolts (9) and remove filter base (4) from bracket (7).
5. If necessary, remove bolts (8) and remove bracket (7) from the cylinder block.

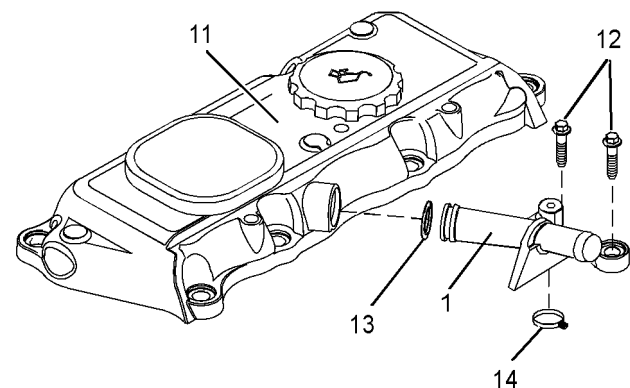


Illustration 144

g01421511

6. Remove bolt (12) and remove breather tube (1) from valve mechanism cover (11).
7. Remove O-ring seal (13) and O-ring seal (14) from breather tube (1).

Disassembly Procedure

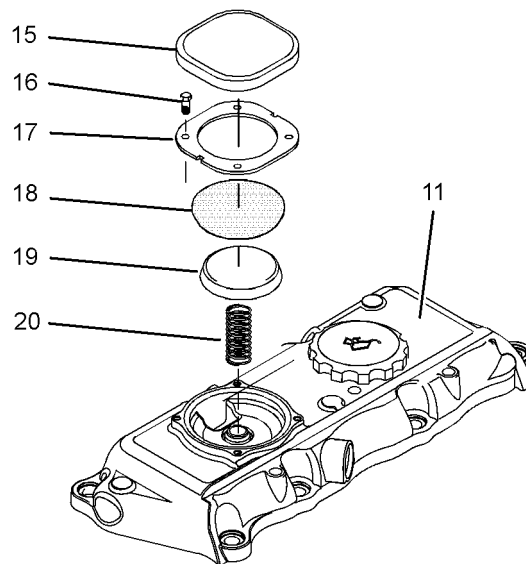


Illustration 145

g01421512

WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

1. Remove plastic cover (15) from valve mechanism cover (11).
2. Remove screws (16). Remove plate (17).
3. Remove assembly of diaphragm (18) and the cap (19). Remove spring (20).

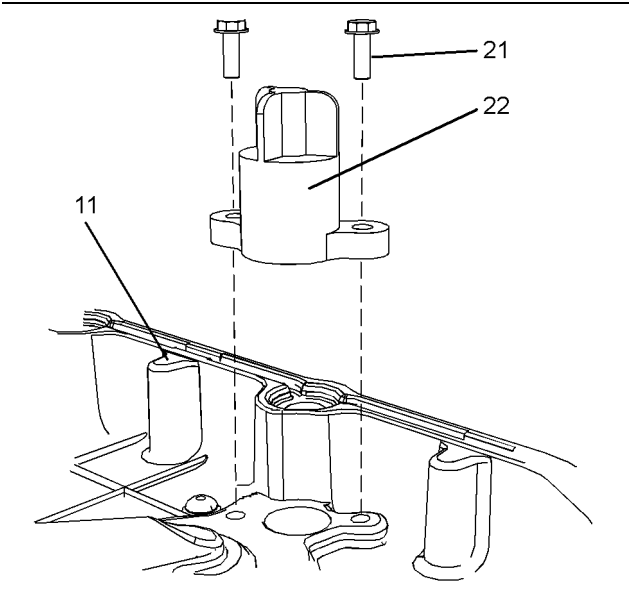


Illustration 146 g01444554

4. If necessary, remove the shut off valve from the valve mechanism cover (11). Follow Steps 4.a through 4.c in order to remove the shut off valve from the valve mechanism cover.
- a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install”.
 - b. Remove bolts (21) from shut off valve assembly (22).
 - c. Remove shut off valve assembly (22) from the valve mechanism cover (11).

Assembly Procedure

Table 42

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610296	Torque Wrench	1

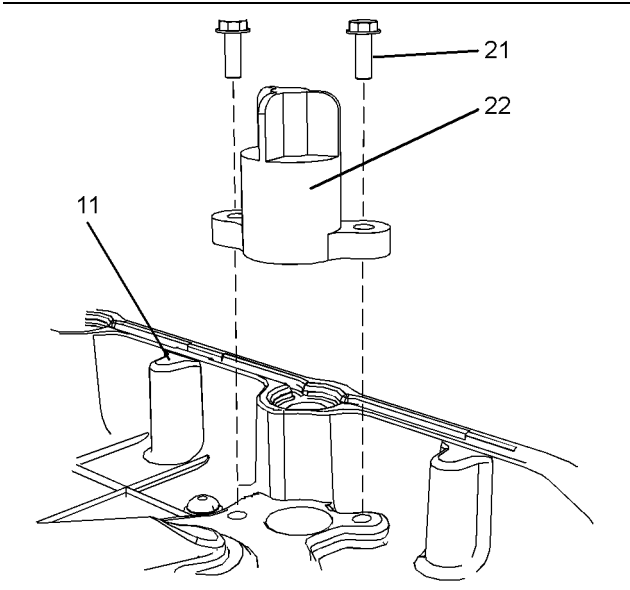


Illustration 147 g01444554

1. If necessary, install shut off valve assembly to the valve mechanism cover (5). Follow Steps 1.a through 1.f in order to install shut off valve assembly to the valve mechanism cover.
- a. Ensure that all components of the shut off valve assembly are clean and free from damage. Replace any components that are damaged.
 - b. The ball in shut off valve assembly (22) must be free to move.
 - c. Install shut off valve assembly (22) to the valve mechanism cover (11).
 - d. Install bolts (21) to shut off valve assembly (22).
 - e. Use Tooling (A) to tighten bolts (21) to a torque of 1.3 N·m (12 lb in).
 - f. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install”.

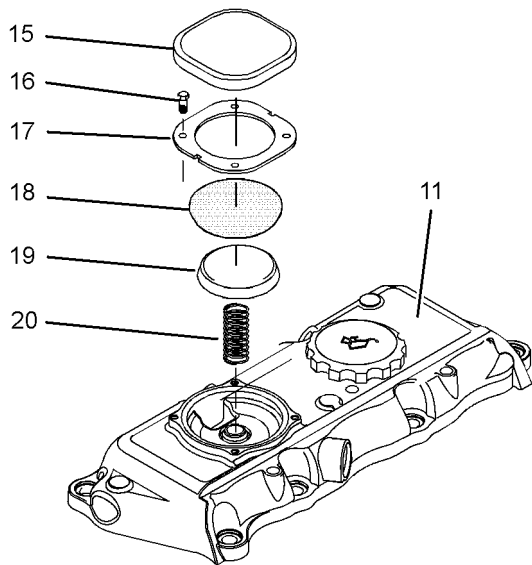


Illustration 148

g01421512

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

2. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
3. Install spring (20). Install assembly of diaphragm (18) and cap (19).
4. Position plate (17) on valve mechanism cover (11) and install screws (16).
5. Use Tooling (A) to tighten bolts (16) to a torque of 1.3 N·m (12 lb in).
6. Install plastic cover (15) to valve mechanism cover (11).

Installation Procedure

Table 43

Required Tools			
Tool	Part Number	Part Description	Qty
B	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

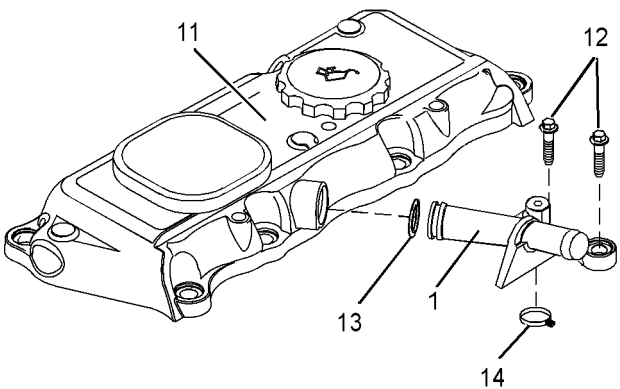


Illustration 149

g01421511

1. Install new O-ring seal (13) and O-ring seal (14) to breather tube (1). Use Tooling (B) in order to lubricate the O-ring seal (13).
2. Install breather tube (1) to valve mechanism cover (11). Install bolt (12) and tighten the bolt to a torque of 9 N·m (80 lb in).

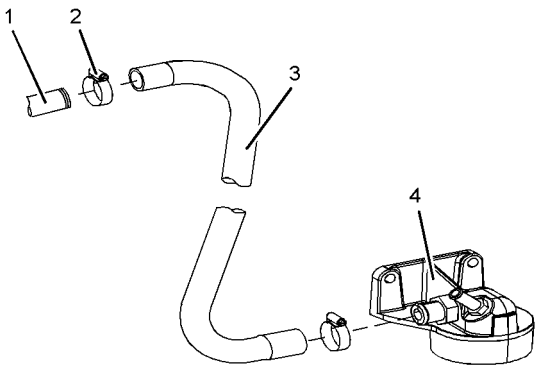


Illustration 150

g01443707

Typical example

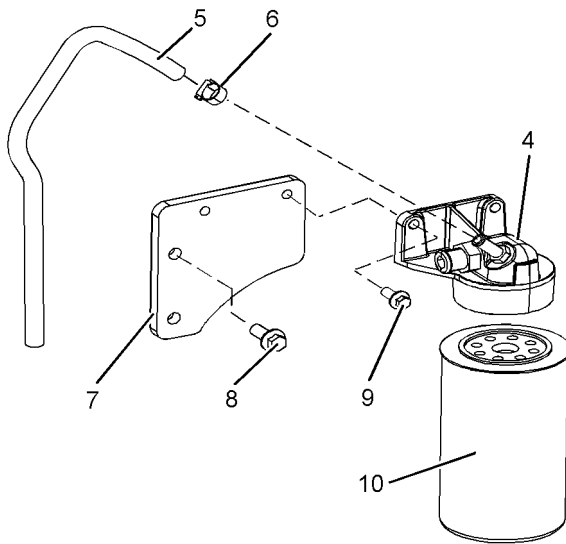


Illustration 151

g01443702

Typical example

3. If necessary, install bracket (7). Position the bracket onto the cylinder block and install bolts (8). Tighten the bolts to a torque of 44 N·m (32 lb ft).
4. Position filter base (4) onto bracket (7) and install bolts (9). Tighten bolts (9) to a torque of 22 N·m (16 lb ft).
5. Install clips (2) to hose (3). Install hose (3) to connection (1) on the valve mechanism cover and to filter base (6). Tighten the clips securely.
6. Install clip (6) to hose (5). Install the hose to filter base (4). Tighten the clips securely.
7. Install a new canister (10) to filter base (4). Refer to Operation and Maintenance Manual, "Crankcase Breather (Canister) - Replace".

i02746348

Valve Mechanism Cover - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. If the engine is equipped with a cover for the fuel injectors, remove the cover for the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".

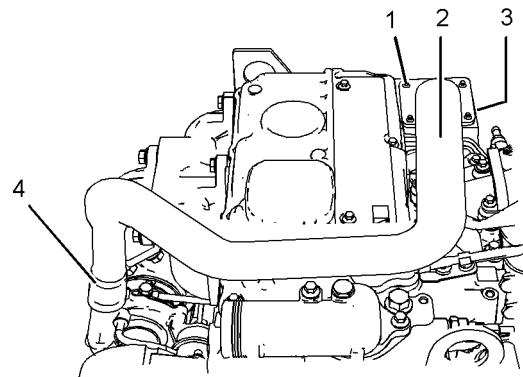


Illustration 152

g01419266

Typical example

2. If the engine is equipped with a air pipe, loosen the hose clamp (4) and remove bolts (1). Remove air pipe (2) and remove the gasket (3) (not shown) from the cylinder head.

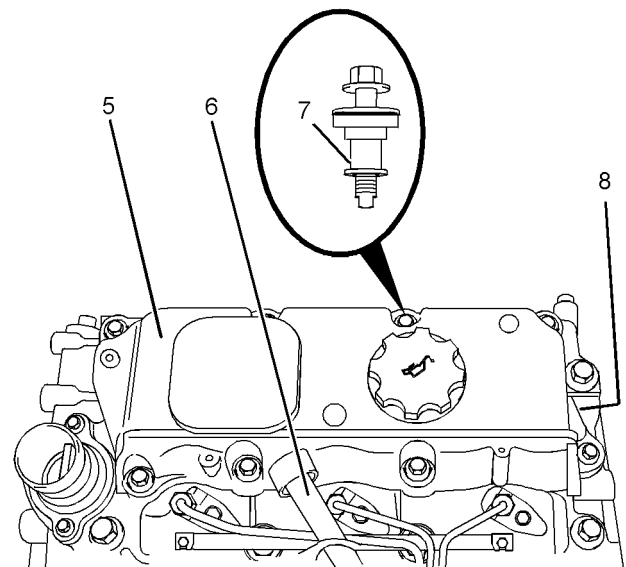


Illustration 153

g01420034

Typical example

3. Remove breather tube (6) from valve mechanism cover (5). Refer to Disassembly and Assembly, "Crankcase Breather - Remove and Install".
4. Loosen captive bolts (7). Remove valve mechanism cover (5).
5. Remove captive bolts (7) and remove joint (8) (not shown) from valve mechanism cover (5).

Installation Procedure

Table 44

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	POWERPART Threadlock and Nutlock	1

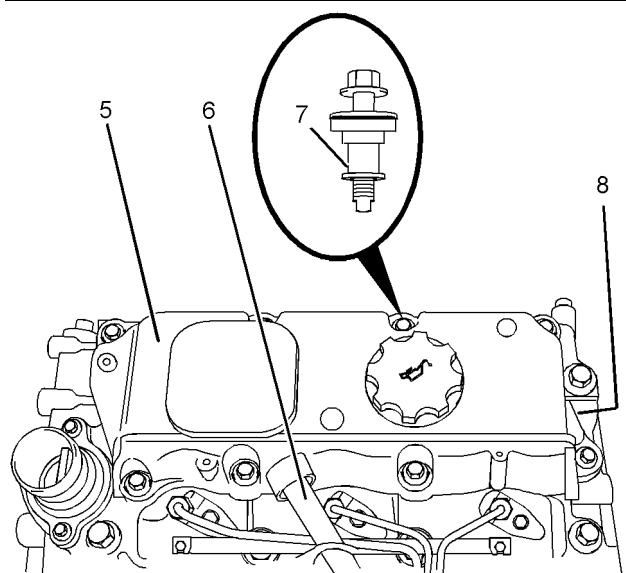


Illustration 154

g01420034

Typical example

1. Thoroughly clean valve mechanism cover (5). Ensure that the groove for the joint in the valve mechanism cover is clean and dry. Ensure that the mating surface on the cylinder head is clean and dry.
2. Check the condition of captive bolts (7). If necessary, replace the captive bolts.
3. Install a new joint (8) to valve mechanism cover (5). Ensure that the joint is seated correctly in the groove in the valve mechanism cover.
4. Install captive bolts (7) to valve mechanism cover (5).

5. Position valve mechanism cover (5) onto the cylinder head.

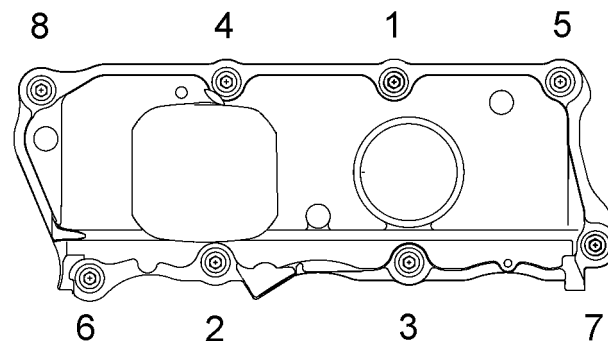


Illustration 155

g01382349

Sequence for tightening the captive bolts

6. Tighten the captive bolts for the valve mechanism cover in the sequence that is shown in Illustration 155. Tighten the captive bolts to a torque of 9 N·m (80 lb in).
7. Install breather tube (6) to valve mechanism cover (5). Refer to Disassembly and Assembly, "Crankcase Breather - Remove and Install".

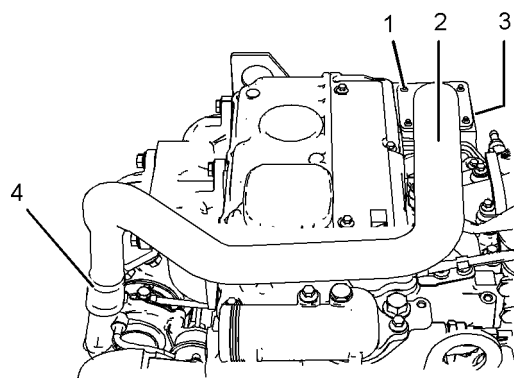


Illustration 156

g01419266

Typical example

8. If the engine was equipped with a air pipe, install air pipe (2) and a new gasket (3) (not shown) to the cylinder head. Apply Tooling (A) to bolts (1) for the air pipe. Install bolts, and tighten the bolts to a torque of 22 N·m (16 lb ft).
9. If the engine is equipped with a cover for the fuel injectors, install the cover for the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".

i02746349

Rocker Shaft and Pushrod - Remove

Removal Procedure

Table 45

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1
B	27610227	Rocker Assembly Tool	3

Start By:

- a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

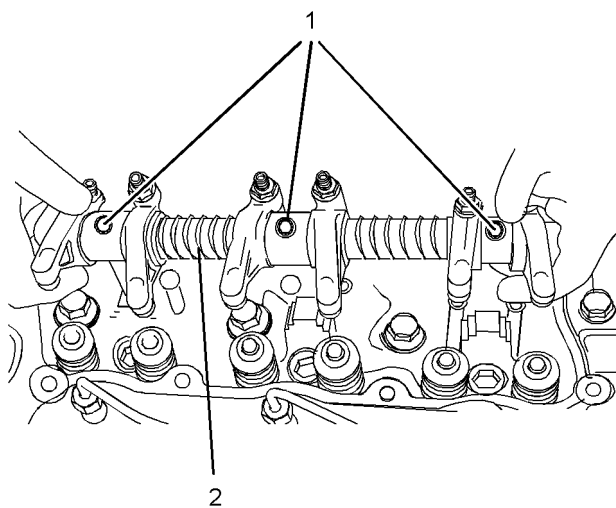


Illustration 157

g01382368

Typical example

1. Use Tooling (A) to progressively loosen torx screws (1). Begin at the ends of the rocker shaft assembly and work toward the center.

Note: To avoid distortion of the rocker shaft assembly, each torx screw should be loosened by a quarter of a turn at one time. Repeat the procedure until all torx screws are loosened.

2. Remove torx screws (1) from rocker shaft assembly (2).
3. If the rocker shaft will not be disassembled, install Tooling (B) between each pair of rocker arms.
4. Remove rocker shaft assembly (2) from the cylinder head.

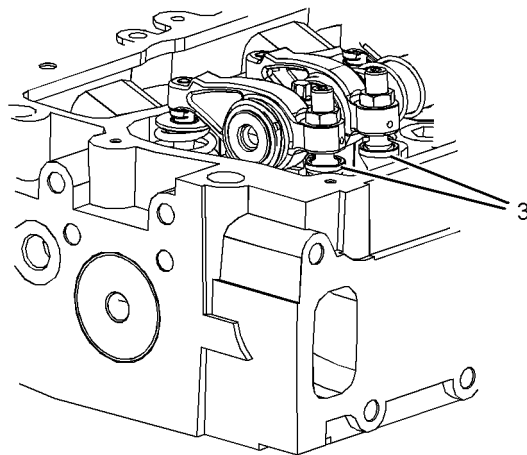


Illustration 158

g01359104

Typical example

5. Place an identification mark on pushrods (3) in order to show the location. Remove the pushrods from the cylinder head.

Note: Identification will ensure that the pushrods can be reinstalled in the original positions. Do not interchange the positions of used pushrods.

i02746350

Rocker Shaft - Disassemble

Disassembly Procedure

Table 46

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1

Start By:

- a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Make an identification Mark on each rocker arm assembly in order to show the location.

Note: The components must be reinstalled in the original location. Do not interchange components.

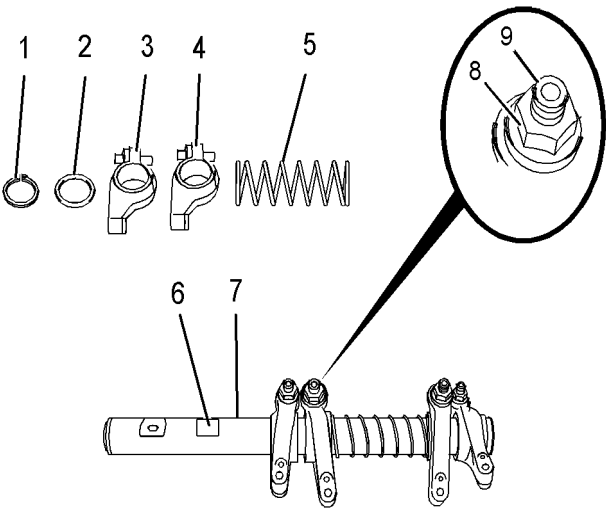


Illustration 159

g01399919

Typical example

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

2. Use Tooling (A) to remove circlip (1) and remove washer (2) from both ends of the rocker shaft assembly.

Note: The rocker shaft (7) is not symmetrical as there is a machined flat (6) toward one end of the shaft.

3. Remove rocker arm assembly (3) for the inlet valve from rocker shaft (7). Remove rocker arm assembly (4) for the exhaust valve from rocker shaft (7).

4. Remove spring (5) from rocker shaft (7).

5. Repeat Step3 and Step4 in order to completely disassemble the rocker shaft assembly.

6. If necessary, remove nuts (8) and adjusters (9) from the rocker arms. Make a temporary identification Mark on each adjuster in order to show the location.

Note: The components must be reinstalled in the original location. Do not interchange components.

i02746351

Rocker Shaft - Assemble

Assembly Procedure

Table 47

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. Refer to Specifications, "Rocker Shaft" for more information. If necessary, replace any components that are worn or damaged.

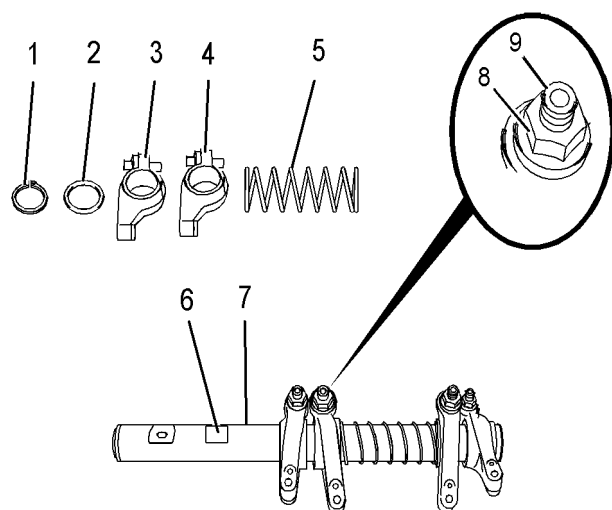


Illustration 160
Typical example

g01399919

WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

2. If necessary, install adjusters (9) and nuts (8) to rocker arm assemblies (3) and (4). If the original adjusters are reused, ensure that the adjusters are installed in the original positions.
3. Use Tooling (A) to install circlip (1) and washer (2) to the front end of rocker shaft (7).
4. Lubricate the bores of rocker arm assemblies (3) and (4) and rocker shaft (7) with clean engine oil.
5. Install rocker arm assembly (3) for number 1 cylinder inlet valves to the rocker shaft. Install rocker arm assembly (4) for number 1 cylinder exhaust valves to rocker shaft (7).
6. Install spring (5) to rocker shaft (7).
7. Repeat Steps 5 to 6 in order to assemble the remaining components to rocker shaft (7).
8. Install washer (2) to rocker shaft (7). Use Tooling (A) to install circlip (1).

End By:

- a. Install the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Install".

i02746352

Rocker Shaft and Pushrod - Install

Installation Procedure

Table 48

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1
B	27610227	Rocker Assembly Tool	3

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the pushrods. Inspect the pushrods for wear or damage. Replace any pushrods that are worn or damaged.
 2. Apply clean engine lubricating oil to both ends of the pushrods. Install the pushrods to the engine with the cup upward.
- Note:** Ensure that the pushrods are installed in the original location and that the ball end of each pushrod is correctly seated in the valve lifters.
3. Ensure that the rocker shaft assembly is clean and free from wear or damage.
 4. If the rocker shaft assembly was disassembled, install Tooling (B) between each pair of rocker arms.

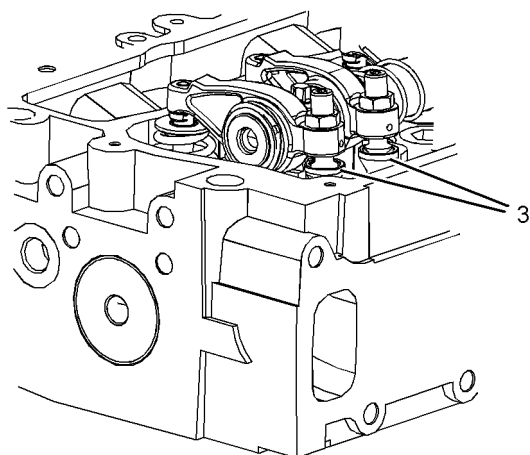


Illustration 161
Typical example

g01359104

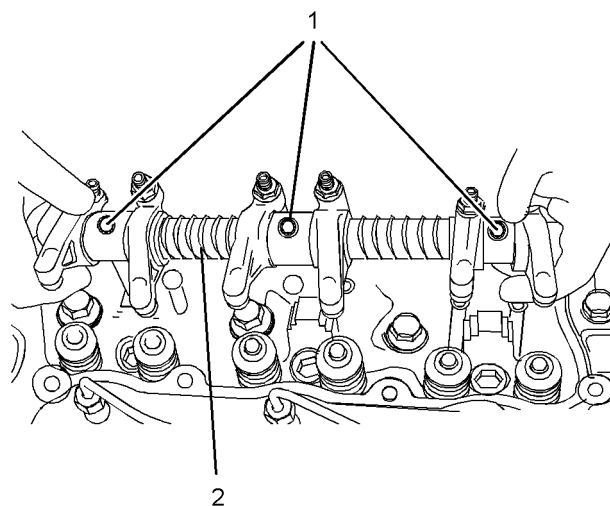


Illustration 163
Typical example

g01382368

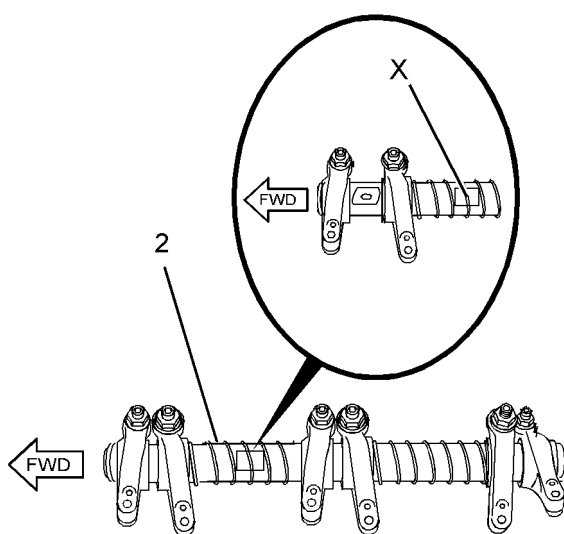


Illustration 162
Typical example

g01399882

5. Ensure that the Machined Flat (X) is facing upward, and facing the front end of the engine.
6. Position rocker shaft assembly (2) onto the cylinder head.

Note: Ensure that adjustment screws are properly seated in the ends of pushrods (3).

7. Install torx screws (1) to the rocker shaft assembly finger tight.
8. Use Tooling (A) to progressively tighten torx screws (1). Begin at the center of the rocker shaft assembly and work toward the ends.

Note: To avoid distortion of the rocker shaft assembly, each torx screw should be tightened by a quarter of a turn at one time. Repeat the procedure until all torx screws are tightened.

Tighten torx screws (1) to a torque of 35 N·m (26 lb ft).

9. Check the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust". If necessary, adjust the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust" for the correct procedure.

End By:

- a. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

i02746353

Cylinder Head - Remove

Removal Procedure

Start By:

- a. Remove the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
- b. Remove the injectors. Refer to Disassembly and Assembly, "Injector - Remove".
- c. Remove the rocker shaft assembly and the pushrods. Refer to this Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".
- d. Remove the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Put identification marks on all hoses, on all hose assemblies, on wires and on all tube assemblies for installation purposes. Plug all hose assemblies and tube assemblies. This helps to prevent fluid loss and this helps to keep contaminants from entering the system.

1. If the alternator bracket is mounted on the cylinder head, remove the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
2. If the fuel priming pump and the fuel filter base are mounted on the cylinder head, remove the fuel priming pump and the fuel filter base. Refer to Disassembly and Assembly, "Fuel Priming Pump and Fuel Filter Base - Remove and Install".

3. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.
4. Disconnect the upper radiator hose from the water temperature regulator housing.
5. If necessary, remove the air hose from the inlet connection.

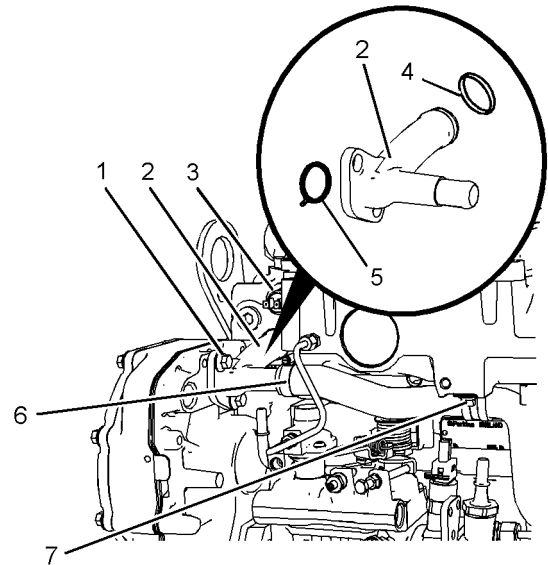


Illustration 164

g01420416

Typical example

6. Disconnect the harness assembly from sensor (3).
7. Loosen hose clamp (6) and remove hose from the bypass tube. Remove bolt (7) from the clip and position the hose away from the cylinder head.
8. Remove bolts (1) that secure bypass tube (2). Remove bypass tube (2). Remove O-ring seals (4) and O-ring seals (5) from bypass tube (2).

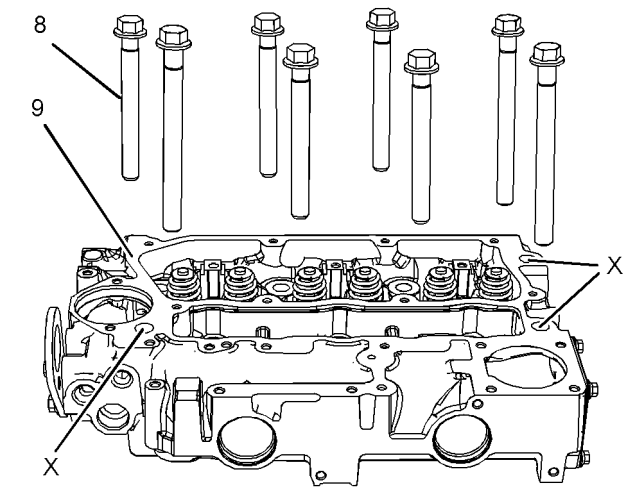


Illustration 165

g01399934

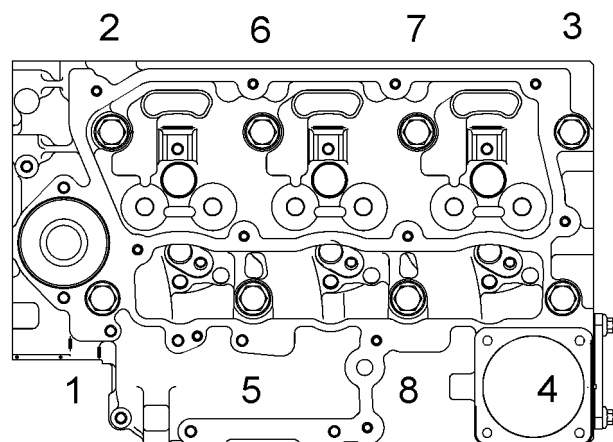


Illustration 166

g01399935

Sequence for loosening the bolts for the cylinder head

9. Gradually loosen bolts (8) in the reverse numerical order to the sequence that is shown in Illustration 166.

Note: Follow the correct sequence in order to help prevent distortion of the cylinder head.

10. Remove bolts (8) from cylinder head (9).

Note: The bolts are two different lengths. Longer cylinder head bolts in Positions (X).

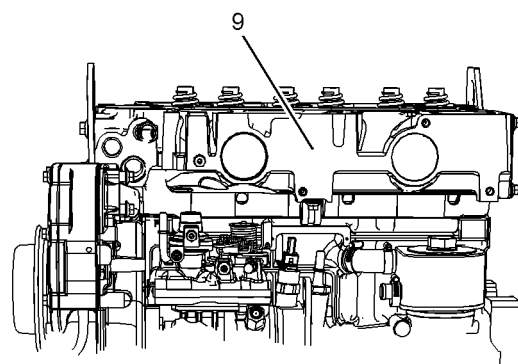


Illustration 167

g01400010

Typical example

11. Attach a suitable lifting device to cylinder head (9). Support the weight of the cylinder head. The weight of the cylinder head is approximately 56 kg (124 lb).

12. Use the lifting device to carefully lift cylinder head (9) off the cylinder block.

Note: Do not use a lever to separate the cylinder head from the cylinder block. Take care not to damage the machined surfaces of the cylinder head during the removal procedure.

NOTICE

Place the cylinder head on a surface that will not scratch the face of the cylinder head.

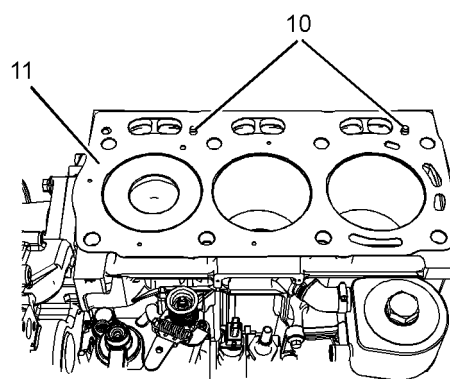


Illustration 168

g01400033

Typical example

13. Remove cylinder head gasket (11).

14. Note the position of dowels (10) in the cylinder block. Do not remove the dowels unless the dowels are damaged.

15. If necessary, remove the sensor from cylinder head.

16. If necessary, remove the water temperature regulator from the cylinder head. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".

i02746354

Cylinder Head - Install

Installation Procedure

Table 49

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (M16 by 115mm)	2
B	-	Straight Edge	1
C	21825607	Degree Wheel	1
D	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean the mating surfaces of the cylinder head and the cylinder block. Do not damage the mating surfaces of the cylinder head or the cylinder block. Ensure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.
2. Inspect the mating surface of the cylinder head for distortion. Refer to Specifications, "Cylinder Head" for more information.

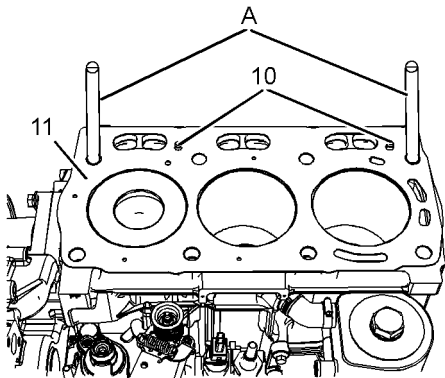


Illustration 169

g01400124

Typical example

3. Inspect dowels (10) for damage. If necessary, replace the dowels in the cylinder block.
4. Install Tooling (A) to the cylinder block. Refer to Illustration 169.
5. Align cylinder head gasket (11) with Tooling (A) and with dowels (10). Install the cylinder head gasket onto the cylinder block.

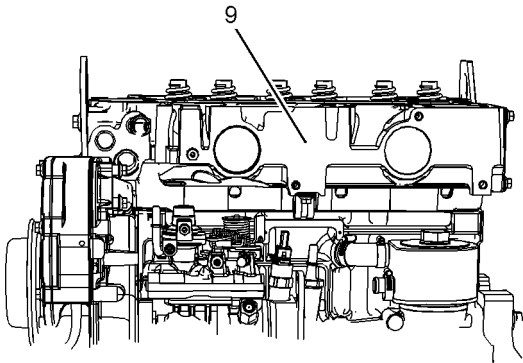


Illustration 170

g01400010

Typical example

6. Use a suitable lifting device to lift the cylinder head. The weight of the cylinder head is approximately 56 kg (124 lb).
7. Use Tooling (A) to align cylinder head (9) with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned onto the dowels.

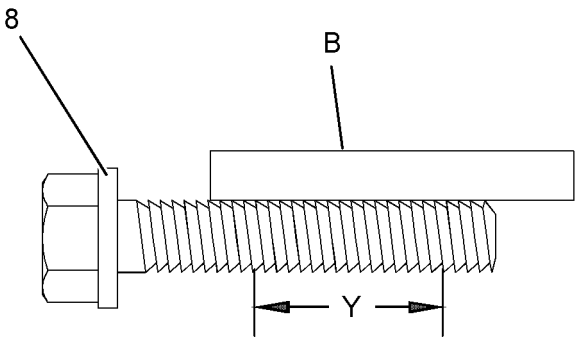


Illustration 171

g01420845

8. Clean bolts (8). Follow Steps 8.a and 8.b for the procedure to inspect the bolts.
 - a. Check the length of the bolts.
 - b. Use Tooling (B) in order to check the threads of the bolts. Refer to Illustration 171. Replace any bolts that show visual reduction in the diameter of the thread over Length (Y).

9. Lubricate the threads and the shoulder of bolts (8) with clean engine oil.

10. Remove Tooling (A).

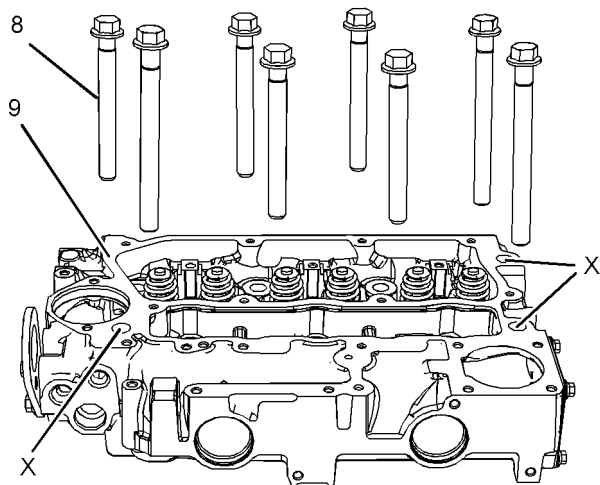


Illustration 172

g01399934

11. Install bolts (8) to cylinder head (9).

Note: There are two different lengths of bolts (8) for cylinder head (9). Install longer bolts in Position (X) in the cylinder head.

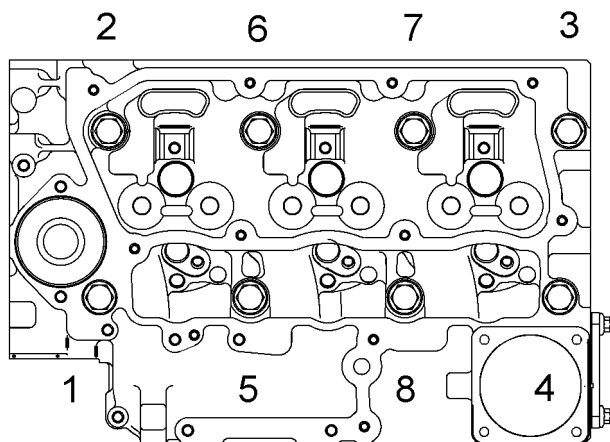


Illustration 173

g01399935

Sequence for tightening the bolts for cylinder head

12. Tighten bolts (8) to a torque of 50 N·m (37 lb ft) in the sequence that is shown in Illustration 173.

13. Tighten bolts (8) to a torque of 100 N·m (74 lb ft) in the sequence that is shown in Illustration 173.

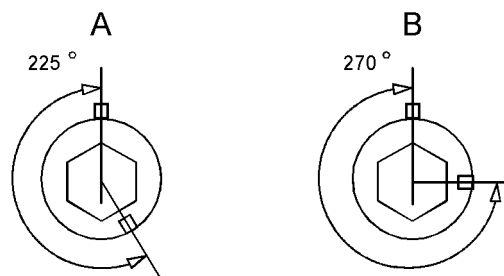


Illustration 174

g01352369

(A) Short bolts

(B) Long bolts

14. Use Tooling (C) to turn bolts (8) through an additional angle in the sequence that is shown in Illustration 173.

Turn the long bolts through 270 degrees.

Turn the short bolts through 225 degrees.

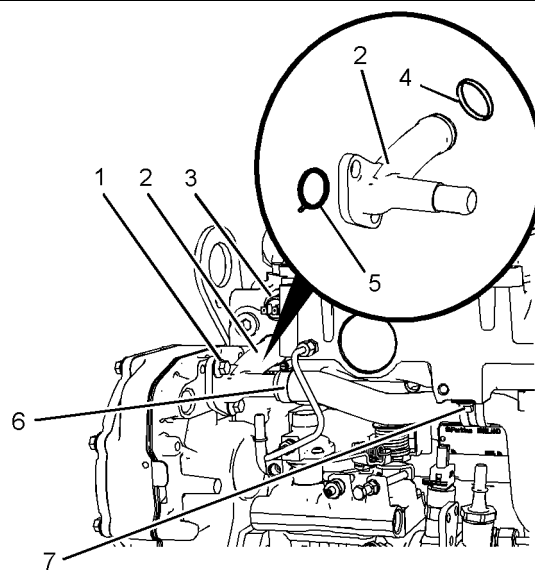


Illustration 175

g01420416

Typical example

15. Install new O-ring seal (4) and O-ring seal (5) to bypass tube (2). Use Tooling (D) in order to lubricate the O-ring seal (4). Install the bypass tube to the cylinder head. Install bolts (1). Tighten the bolts to a torque of 22 N·m (16 lb ft).

i02746411

16. Install hose to bypass tube (2) and securely tighten hose clamp (6). Position the clip for the hose onto the cylinder head. Install bolt (7). Tighten the bolts to a torque of 22 N·m (16 lb ft).
17. Connect the harness assembly to sensor (3).
18. If the alternator bracket is mounted on the cylinder head, install the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
19. If the fuel priming pump and the fuel filter base are mounted on the cylinder head, install the fuel priming pump and the fuel filter base. Refer to Disassembly and Assembly, "Fuel Priming Pump and Fuel Filter Base - Remove and Install".
20. If necessary, install the water temperature regulator housing to the cylinder head. Refer to Disassembly and Assembly, "Water Temperature Regulator Housing - Remove and Install".
21. Connect the upper radiator hose to the water temperature regulator housing .
22. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.
23. If necessary, fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check".
24. If necessary, install the air hose to the inlet connection.

End By:

- a. Install the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
- b. Install the rocker shaft assembly and the pushrods. Refer to this Disassembly and Assembly Manual, "Rocker Shaft and Pushrod - Install".
- c. Install the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".
- d. Install the injectors. Refer to Disassembly and Assembly, "Injector - Install".

Lifter Group - Remove and Install

Removal Procedure

Table 50

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
B	-	Telescoping Magnet	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- b. Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to lifters (1).

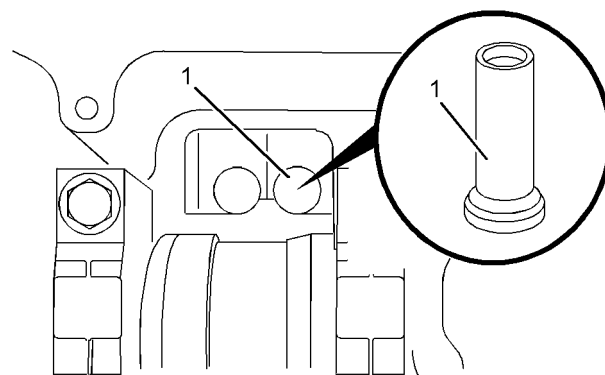


Illustration 176

g01340518

Typical example

2. Use Tooling (B) in order to remove lifters (1).

Note: Make a temporary identification mark on each lifter in order to identify the correct location.

3. Repeat Steps 1 and 2 in order to remove the remaining lifters.

Installation Procedure

Table 51

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
B	-	Telescoping Magnet	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

It is strongly recommended that all lifters should be replaced when a new camshaft is installed.

1. Clean the lifters. Follow Steps 1.a through 1.c in order to inspect the lifters. Replace lifters that are worn or damaged.
 - a. Inspect the seat of the pushrod in the lifter for visual wear or damage.
 - b. Inspect the shank of the lifter for wear or damage. Refer to Specifications, "Lifter Group" for more information.
 - c. Inspect the face of the lifter that runs on the camshaft for visual wear or damage.
2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft. Rotate the crankshaft to access to the cylinder block in order to install lifters (1).
3. Lubricate lifters (1) with clean engine oil.

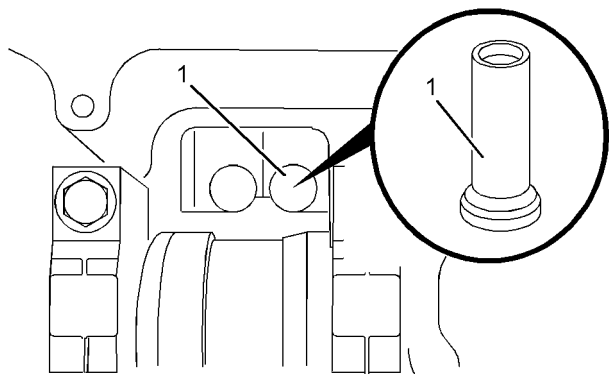


Illustration 177

Typical example

g01340518

4. Use Tooling (B) to install lifters (1) to the cylinder block. Ensure that used lifters are installed in the correct location.

Note: The lifters should be free to rotate.

5. Repeat Steps 1 and 4 in order to install the remaining lifters.

End By:

- a. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".
- b. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02746414

Camshaft - Remove and Install

Removal Procedure

Start By:

- a. Remove the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rocker shaft and Pushrod - Remove".
- b. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. The engine should be mounted on a suitable stand and placed in the inverted position.

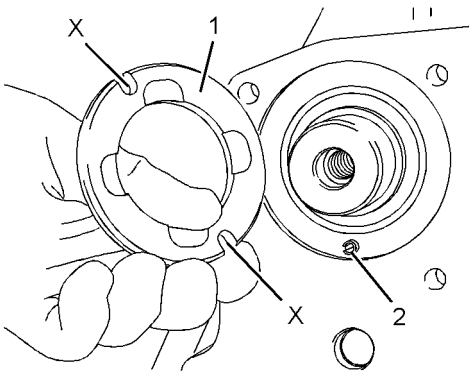


Illustration 178

g01439275

2. Remove thrust washer (1) from the cylinder block. Do not remove dowel (2) from the cylinder block unless the dowel is damaged.

Note: The thrust washer can have one or two Slots (X).

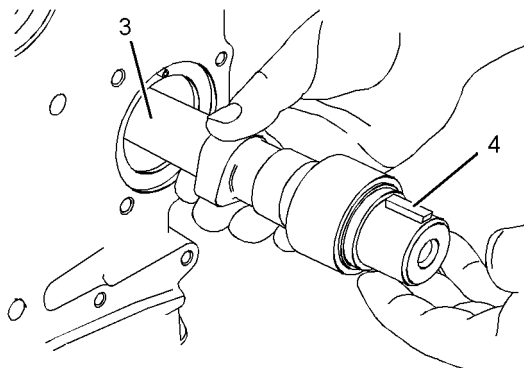


Illustration 179

g01266057

NOTICE

Do not damage the lobes or the bearings when the camshaft is removed or installed.

3. Carefully remove camshaft (3) from the cylinder block.
4. Do not remove key (4) from camshaft (3) unless the key is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the camshaft and the thrust washer. Inspect the camshaft and the thrust washer for wear and for damage. Refer to Specifications, "Camshaft" for more information. Replace any components that are worn or damaged.
2. Clean the camshaft bearing in the cylinder block. Inspect the camshaft bearing for wear and for damage. Refer to Specifications, "Camshaft Bearings" for more information. If necessary, replace the camshaft bearing. Refer to Disassembly and Assembly, "Camshaft Bearing - Remove and Install".

NOTICE

It is strongly recommended that all lifters should be replaced when a new camshaft is installed.

3. Inspect the lifters for wear and for damage. Refer to Specifications, "Lifter Group" for more information. Replace any worn lifters or any damaged lifters. Refer to Disassembly and Assembly, "Lifter Group - Remove and install".

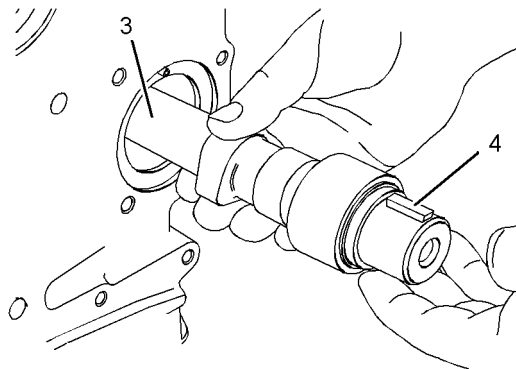


Illustration 180

g01266057

4. If necessary, install a new key (4) to camshaft (3).
5. Lubricate the bearing surfaces of camshaft (3) and lubricate the lobes of the camshaft with clean engine oil.

NOTICE

Do not damage the lobes or the bearings when the camshaft is removed or installed.

6. Carefully install camshaft (3) into the cylinder block.

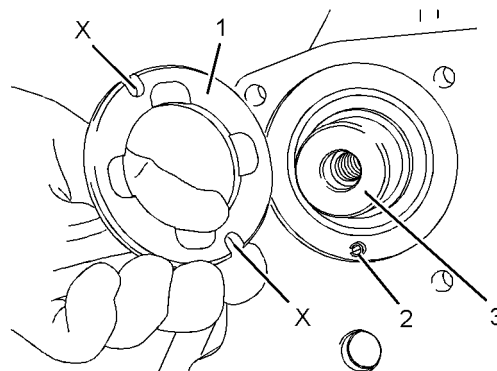


Illustration 181

Typical example

g01266056

7. Lubricate the thrust washer with clean engine oil. Align Slot (X) in thrust washer (1) with dowel (2) in the cylinder block. Install thrust washer (1) into the recess in the cylinder block.

Note: The thrust washer can have one or two slots.

End By:

- a. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- b. Install the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rocker shaft and Pushrod - Install".

i02746418

Camshaft Gear - Remove and Install

Removal Procedure

Table 52

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	27610211	Timing Pin (Crankshaft)	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
- b. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

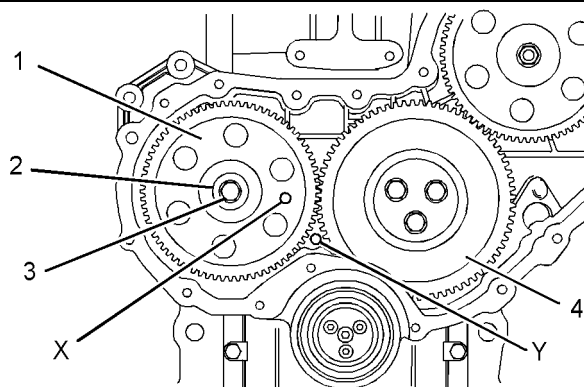


Illustration 182

g01255712

Typical example

2. Install Tooling (B) through Hole (X) in camshaft gear (1) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position.
3. Install Tooling (C) into Hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

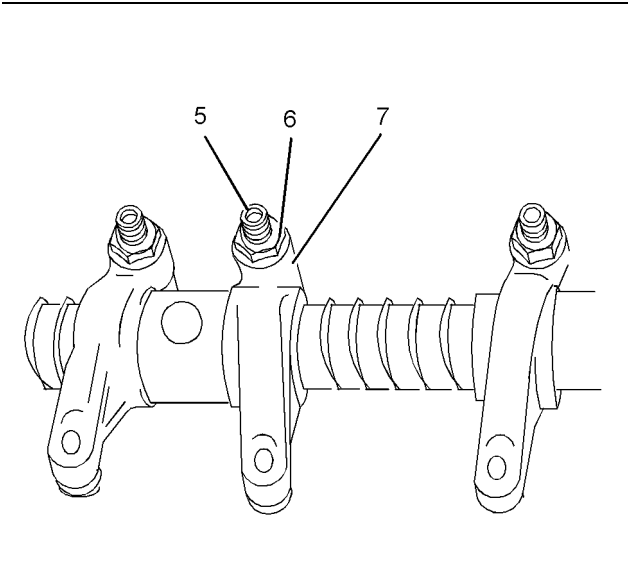


Illustration 183
Typical example

4. Loosen nuts (6) on ALL rocker arms (7). Unscrew adjusters (5) on all rocker arms (7) until all valves are fully closed.

Note: Failure to ensure that all adjusters are fully unscrewed can result in contact between the valves and pistons.

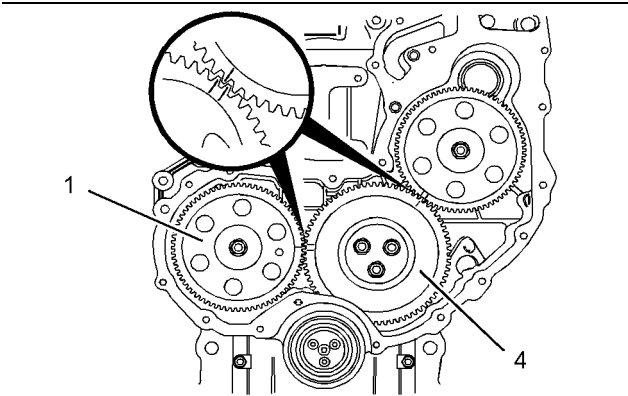


Illustration 184
Alignment of timing Marks

5. Mark gears (1) and (4) in order to show alignment. Refer to Illustration 184.

Note: Identification will ensure that the gears can be installed in the original alignment.

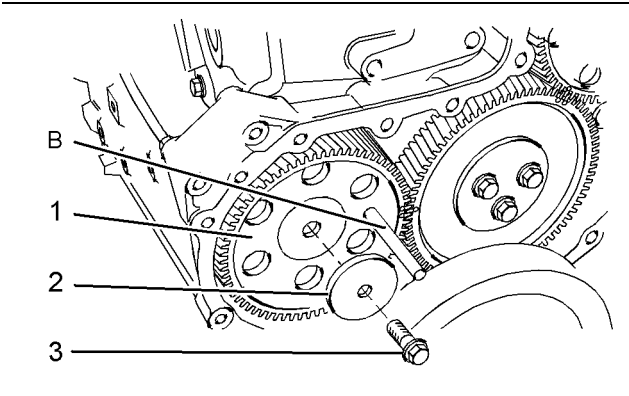


Illustration 185
Typical example

6. Remove Tooling (B) and Tooling (C). Remove bolt (3) and washer (2) from camshaft gear (1).

7. Remove camshaft gear (1) from the camshaft.

Note: If the camshaft gear is a tight fit on the nose of the camshaft, use a prybar in order to remove the camshaft gear.

8. If necessary, remove the key from the nose of the camshaft.

Installation Procedure

Table 53

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1
D	-	Magnetic Base	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

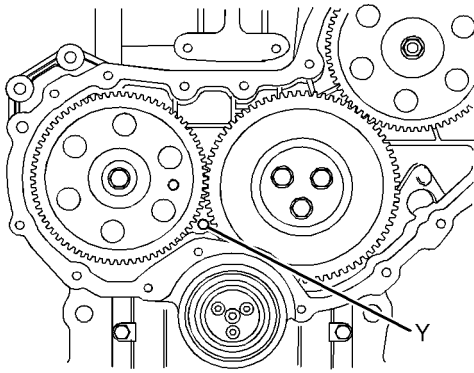


Illustration 186

g01439277

Typical example

2. Install Tooling (C) into Hole (Y) in the cylinder block. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston".
3. Ensure that the camshaft gear and the key are clean and free from wear or damage.
4. If necessary, install the key into the nose of the camshaft.

Note: Ensure that the key is squarely seated.

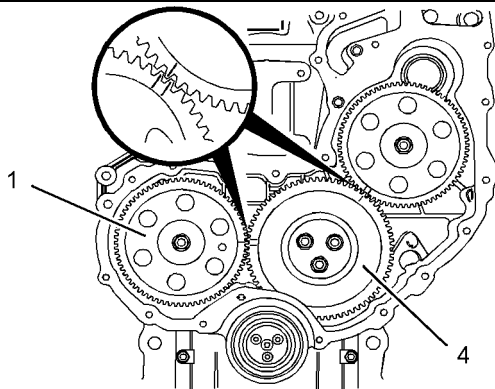


Illustration 187

g01344527

Alignment of timing Marks

5. Align the keyway in camshaft gear (1) with the key in the camshaft. Install the camshaft gear onto the camshaft. Ensure that the timing Marks on gears (1) and (4) are in alignment and that the mesh of the gears is correct. Refer to Illustration 187.

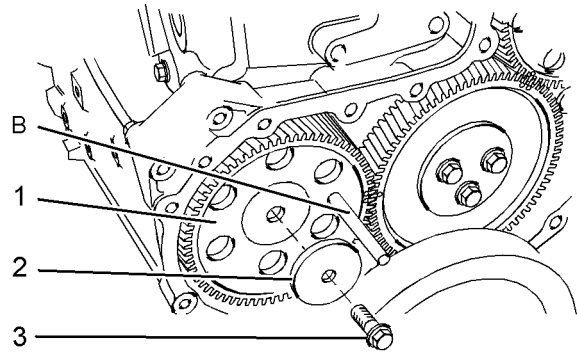


Illustration 188

g01340554

Typical example

6. Install Tooling (B) through Hole (X) in the camshaft gear into the front housing. Install washer (2) and bolt (3) to camshaft gear (1).
7. Remove Tooling (B) and Tooling (C).
8. Tighten bolt (3) to a torque of 95 N·m (70 lb ft).
9. Use Tooling (D) to check the backlash for gears (1) and (4). Ensure that the backlash for the gears is within specified values. Refer to the Specifications, "Gear Group (Front)" for further information.
10. Use Tooling (D) to check the end play for camshaft gear (1). Ensure that the end play is within specified values. Refer to the Specifications, "Camshaft" for further information.
11. Lubricate the teeth of the gears with clean engine oil.
12. Adjust the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust".

End By:

- a. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
- b. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

i02746421

Camshaft Bearings - Remove and Install

Removal Procedure

Table 54

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610275	Bearing Puller	1

Start By:

- Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

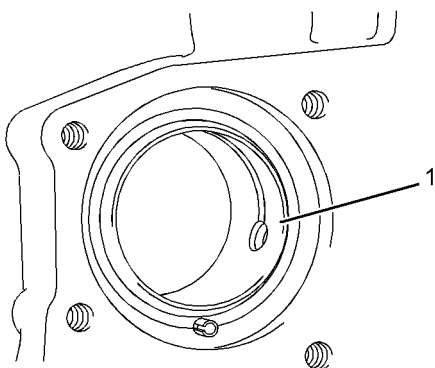


Illustration 189

g01270437

- Inspect camshaft bearing (1). Refer to Specifications, "Camshaft Bearings" for more information.
- If camshaft bearing (1) is worn or damaged use Tooling (A) in order to remove the camshaft bearing from the cylinder block.

Note: Remove the camshaft bearing from the front of the cylinder block.

Installation Procedure

Table 55

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610275	Bearing Puller	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- Clean the bearing housing in the cylinder block. Ensure that the oil holes in the bearing housing are free from debris.

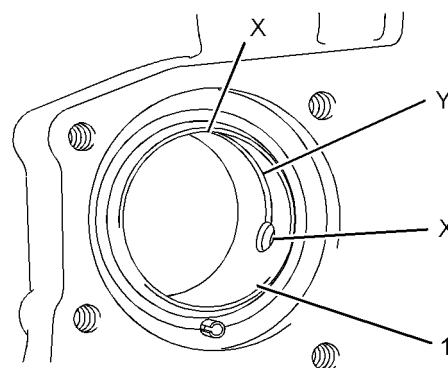


Illustration 190

g01266512

- Lubricate the bearing housing in the cylinder block with clean engine oil.
- Accurately align the two oil Holes (X) in camshaft bearing (1) with the two oil Holes (X) in the cylinder block.

Note: The Groove (Y) in the camshaft bearing must be to the top of the cylinder block.

- Use Tooling (A) in order to install camshaft bearing (1) into the cylinder block. Install the camshaft bearing so that the front edge of the bearing is flush with the face of the recess in the cylinder block.

Note: Ensure that all oil holes are correctly aligned. If the oils are not correctly aligned, the camshaft bearing should be removed.

End By:

- Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".
- Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02746423

Engine Oil Pan - Remove and Install

Removal Procedure

Note: In order to remove a cast iron oil pan, the engine must be removed from the machine. Ensure that the engine lubricating oil is drained. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. The engine should be mounted in a suitable stand and placed in the inverted position.

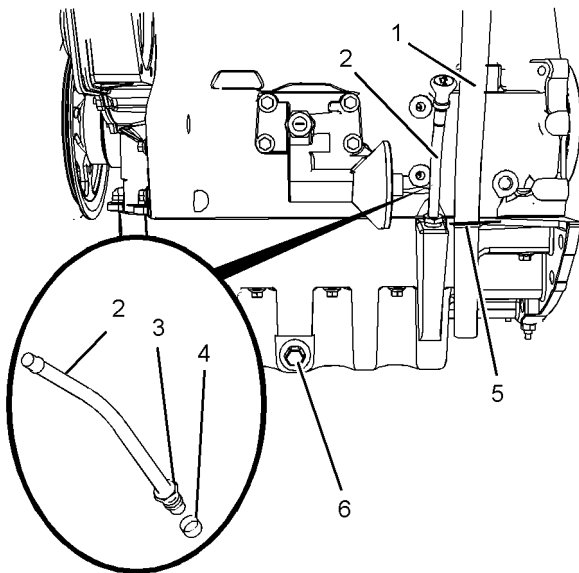


Illustration 191
Typical example

g01400126

2. Disconnect breather hose (1) from clip (5). Position the breather hose away from the engine oil pan.

Note: Identify the position and orientation of the tube assembly before removal.

3. Remove the assembly of the dipstick tube. Loosen nut (3) and remove tube assembly (2). Remove seal (4) from the tube assembly.

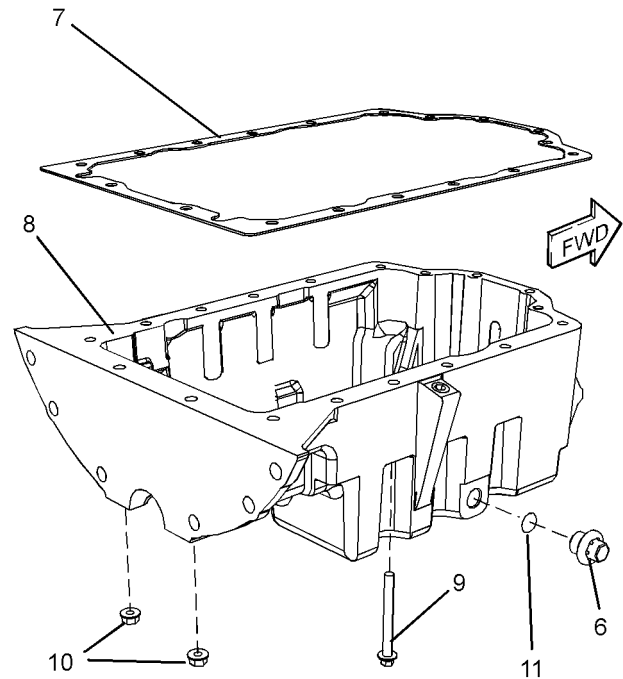


Illustration 192

g01400127

Typical example

4. Mark the position of clip (5). Refer to Illustration 191. Loosen the bolt that secures the clip and remove the clip.

5. Remove nuts (10) and bolts (9).

Note: The bolts are different lengths. Note the position of the different bolts.

6. Attach a suitable lifting device to engine oil pan (8). Support the weight of the engine oil pan. The weight of engine oil pan (8) is approximately 41 kg (90 lb).

7. Use the lifting device to remove engine oil pan (8) from the cylinder block.

8. Remove joint (7) from the cylinder block.

9. If necessary, remove drain plug (6). Remove O-ring seal (11) from oil drain plug (6).

Installation Procedure

Table 56

Required Tools			
Tool	Part Number	Part Description	Qty
A	21826038	POWERPART Silicon Rubber Sealant	-
B	21820117	POWERPART Threadlock and Nutlock	-
C	-	Straight Edge	1

Note: In order to install a cast iron oil pan, the engine must be removed from the machine.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the mating surface of the cylinder block is clean and free from damage. Inspect the studs in the cylinder block for damage. If necessary, replace the studs.
2. Ensure that the engine oil pan is clean and free from damage.

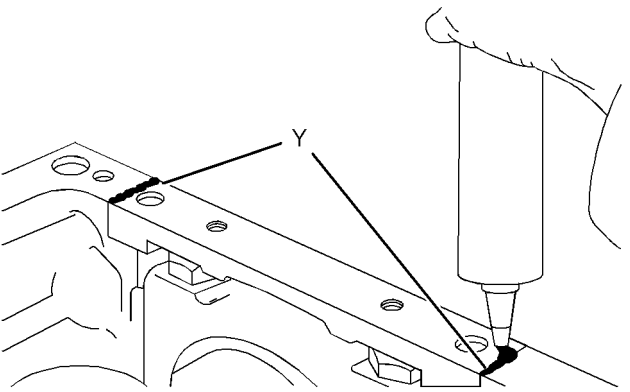


Illustration 193

Typical example

g01251763

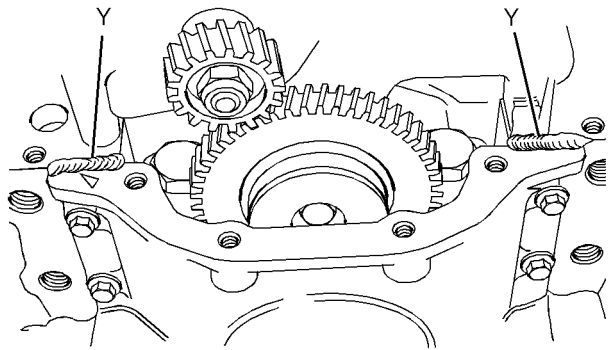


Illustration 194

Typical example

g01251766

3. Apply a bead of Tooling (A) to Positions (Y) on the cylinder block.

Note: If the bridge piece for the cylinder block has just been installed, the engine oil pan must be installed before Tooling (A) has cured.

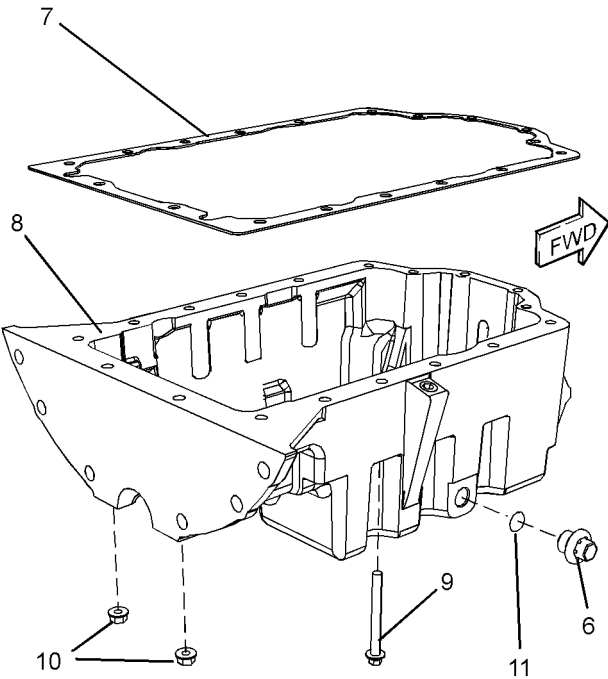


Illustration 195

Typical example

g01400127

4. Align a new joint (7) with the studs in the cylinder block. Install the joint to the cylinder block.
5. Attach a suitable lifting device to engine oil pan (8). The weight of engine oil pan (8) is approximately 41 kg (90 lb).

6. Use the lifting device to align engine oil pan (8) with the studs in the cylinder block. Install the engine oil pan to the cylinder block. Remove the lifting device from the engine oil pan.
7. Install bolts (9) and nuts (10) finger tight. Install the clip (6).

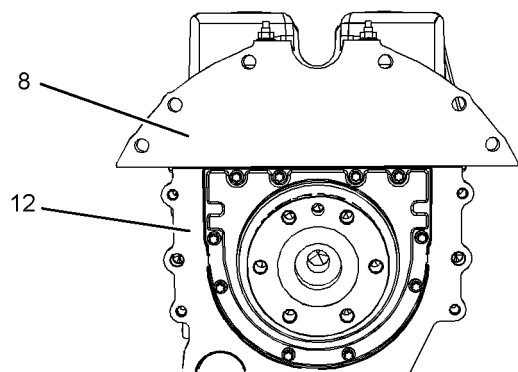


Illustration 196

g01400128

Typical example

8. Align the rear face of engine oil pan (8) to the rear face of cylinder block (12). Use Tooling (C) and a feeler gauge in order to check the alignment between the engine oil pan and the cylinder block.
9. Tighten bolts (9) and nuts (10) to a torque of 22 N·m (16 lb ft).
10. If necessary, install a new O-ring seal (11) to drain plug (5). Install drain plug (5) to engine oil pan (8). Tighten the drain plug to a torque of 34 N·m (25 lb ft).

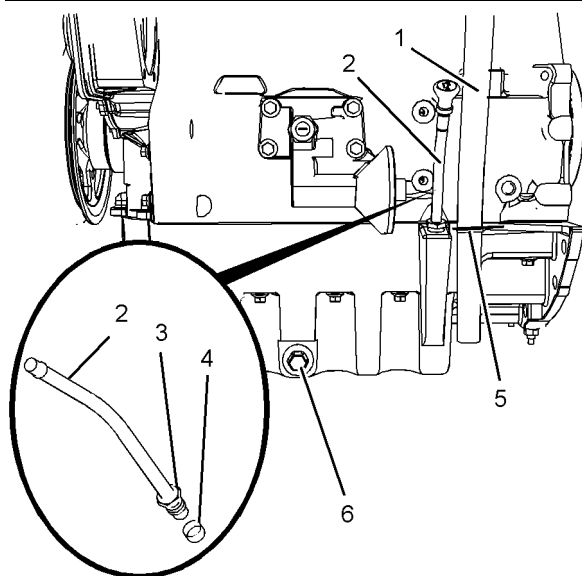


Illustration 197

g01400126

Typical example

11. Follow Steps 11.a through 11.c in order to install the assembly of the dipstick tube.

- a. Install a new seal (4) to tube assembly (2).
- b. Apply Tooling (B) to nut (3). Install the tube assembly to the engine oil pan.

Note: Ensure that the orientation of the tube assembly is correct.

- c. Tighten the nut to a torque of 18 N·m (13 lb ft). Install the dipstick .

12. Install breather hose (1) to clip (5).

13. After the engine has been installed, ensure that the engine oil pan is filled with lubricating oil to the correct level. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.

i02748523

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 57

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to the piston cooling jet.

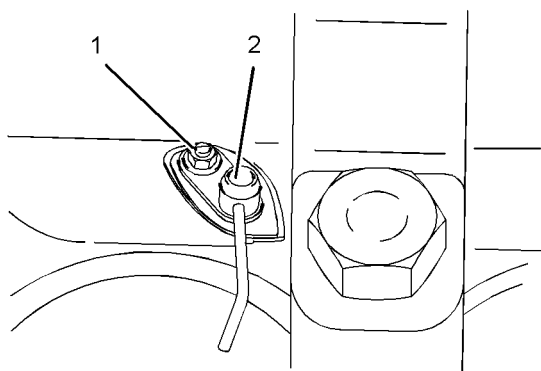


Illustration 198

g01265615

Typical example

2. Remove bolt (1) and piston cooling jet (2) from the cylinder block.
3. Repeat Steps 1 and 2 for the remaining piston cooling jets.

Installation Procedure

Table 58

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

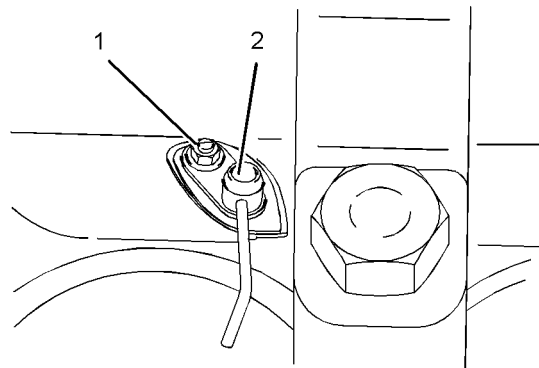


Illustration 199

g01265615

1. Clean the piston cooling jets and inspect the piston cooling jets for damage. Ensure that the valve is free to move within each piston cooling jet. Replace any damaged piston cooling jets.
2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to access the mounting flange for the piston cooling jet.
3. Position piston cooling jet (2) in the cylinder block. Install bolt (1). Tighten the bolt to a torque of 9 N·m (80 lb in).
4. Repeat Steps 2 through 3 for the remaining piston cooling jets.
5. If the cylinder head has been removed, It is possible to check the alignment of the piston cooling jets. Refer to Specifications, "Piston Cooling Jet Alignment" for more information.

Note: It is not possible to check the alignment of the piston cooling jets with the cylinder head in position.

i02746429

Pistons and Connecting Rods - Remove

Removal Procedure

Table 59

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610274	Ridge Reamer	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly , "Cylinder Head - Remove".
- b. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- c. Remove the piston cooling jets. Refer to Disassembly and Assembly , "Piston Cooling Jets - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Use Tooling (A) to rotate the crankshaft until the crank pin is at the bottom center position.
2. Use Tooling (B) to remove the carbon ridge from the top inside surface of the cylinder bore.

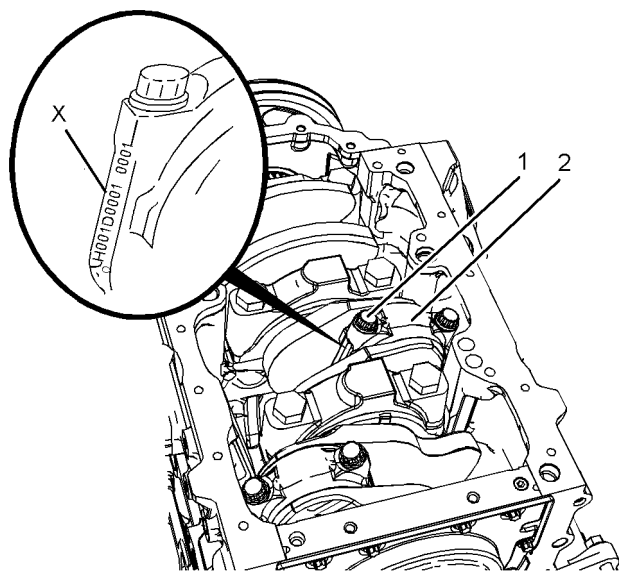


Illustration 200

g01400138

3. The connecting rod and the connecting rod cap should have an etched Number (X) on the side. The number on the connecting rod and the connecting rod cap must match. Ensure that the connecting rod and connecting rod cap (2) are Marked for the correct location. If necessary, make a temporary Mark on the connecting rod and the connecting rod cap in order to identify the cylinder number.

Note: Do not stamp the connecting rod assembly. Stamping or punching the connecting rod assembly could cause the connecting rod to fracture.

4. Remove bolts (1) and remove connecting rod cap (2) from the connecting rod.

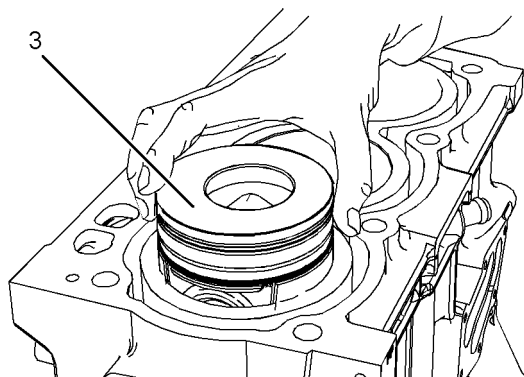


Illustration 201

g01400146

5. Carefully push piston (3) and the connecting rod assembly out of the cylinder bore. Lift the piston out of the top of the cylinder block.

Note: Do not push on the fracture split surfaces of the connecting rod as damage may result.

6. Temporarily install connecting rod cap (2) and bolts (1) to the connecting rod when the assembly is out of the engine. Tighten bolts (1) to a torque of 20 N·m (14 lb ft).

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. Ensure that the etched number on connecting rod cap matches the etched number on connecting rod. Ensure the correct orientation of the connecting rod cap.

7. Repeat Steps 1 through 5 for the remaining pistons and connecting rods.

i02746431

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 60

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Retaining Ring Pliers	1
B	-	Ring Expander	1

Start By:

- a. Remove the pistons and the connecting rods.
Refer to Disassembly and Assembly, "Piston and Connecting Rods - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Make a temporary Mark on the components of the piston and connecting rod assembly. This will ensure that the components of each piston and connecting rod assembly can be reinstalled in the original cylinder. Mark the underside of the piston on the front pin boss. Do not interchange components.

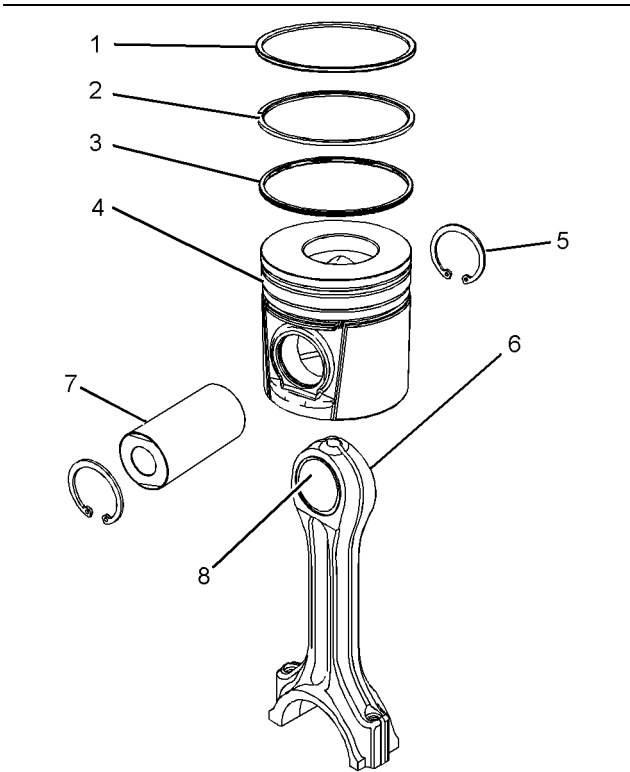


Illustration 202

g01401582

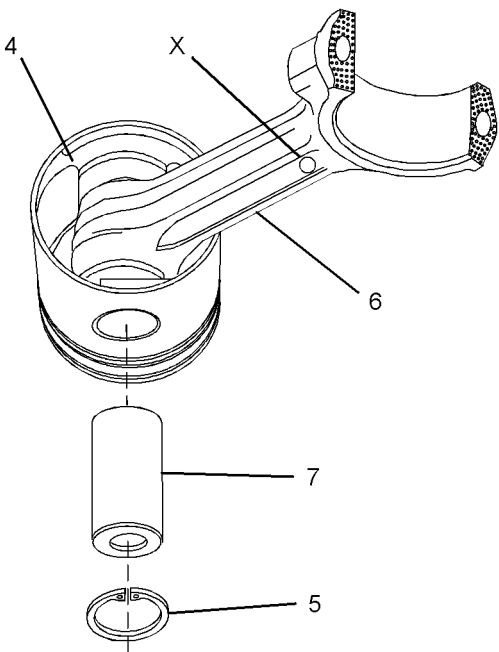


Illustration 203

Typical example

g01421139

2. Place the piston and connecting rod assembly on a suitable surface with the connecting rod upward. Use Tooling (A) in order to remove retaining rings (5).

Note: The forged Marks (X) identify the front of the connecting rod assembly. The forged Marks should be used for the purposes of orientation.

3. Remove piston pin (7) and connecting rod (6) from piston (4).

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of $45 \pm 5^\circ\text{C}$ ($113 \pm 9^\circ\text{F}$). Do not use a torch to heat the piston. Note the orientation of the connecting rod and the piston.

4. Place the piston on a suitable surface with the crown upward. Use Tooling (B) in order to remove compression rings (1) and (2), and oil control ring (3) from piston (4).

Note: Identify the position and orientation of compression rings (1) and (2), and oil control ring (3).

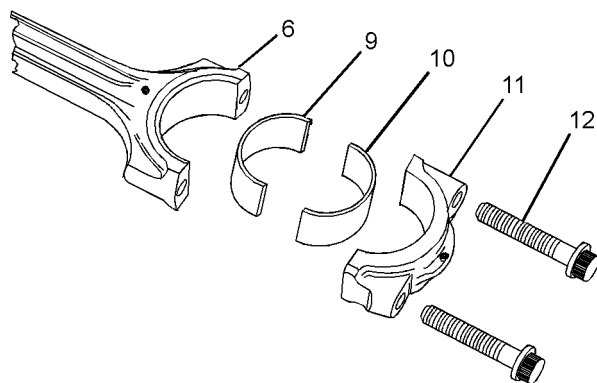


Illustration 204

g01244068

5. Remove bolts (12) and connecting rod cap (11) from connecting rod (6). Discard the bolts.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the disassembly procedure for the piston and connecting rod is completed, carry out the assembly procedure and the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Assemble" and Disassembly and Assembly, "Piston and Connecting Rods - Install".

6. Remove the lower half of connecting rod bearing (10) from connecting rod cap (11). Remove the upper half of connecting rod bearing (9) from connecting rod (6). Keep the bearing shells together.

NOTICE

Removal of the piston pin bushing in the connecting rod must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorized Perkins dealer.

7. Inspect the connecting rod for wear or damage. If necessary, replace connecting rod (6) or replace bush (8) for the piston pin.

Note: If the connecting rod or the bush for the piston pin are replaced, first identify the height grade of the connecting rod. Refer to Specifications, "Connecting Rod".

8. Repeat Steps 1 through 7 in order to disassemble the remaining pistons and connecting rods.

i02746434

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 61

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Retaining Ring Pliers	1
B	-	Ring Expander	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.

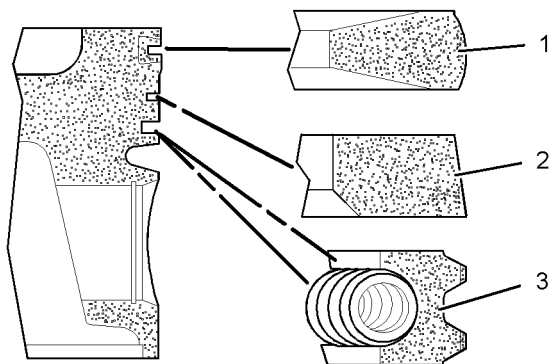


Illustration 205

g01155119

2. If the original piston is assembled, follow Steps 2.a through 2.e in order to install the piston rings.
 - a. Position the spring for oil control ring (3) into the oil ring groove in piston (4). The central wire must be located inside the end of the spring.
 - b. Use Tooling (B) to install oil control ring (3) over the spring.
- Note:** Ensure that the central wire is 180 degrees from the ring gap.
- c. Use Tooling (B) to install intermediate compression ring (2) into the second groove in piston (4). The word "TOP" must be upward. The chamfer on the inner face must be downward.
 - d. Use Tooling (B) to install top compression ring (1) into the top groove in piston (4). The word "TOP" must be upward.
 - e. Position the piston ring gaps at 120 degrees away from each other.

Note: A new piston assembly is supplied with new piston rings.

NOTICE

Removal of the piston pin bushing in the connecting rod must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorized Perkins dealer.

3. If the connecting rod assembly or the bush for the piston pin have been replaced, ensure that the height grade of the connecting rod is correct. Refer to Specifications, "Connecting Rod" for further information.

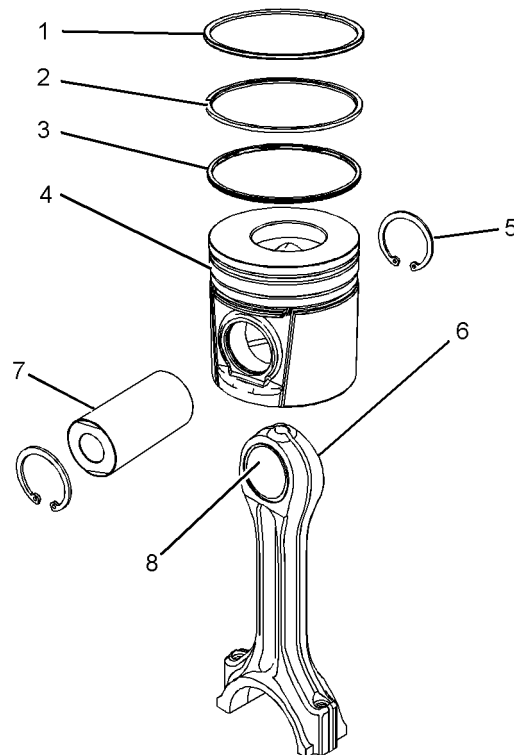


Illustration 206

g01401582

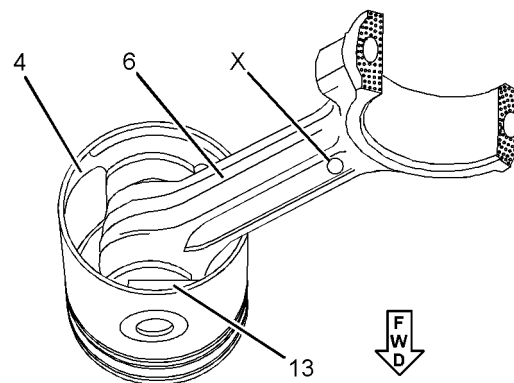


Illustration 207

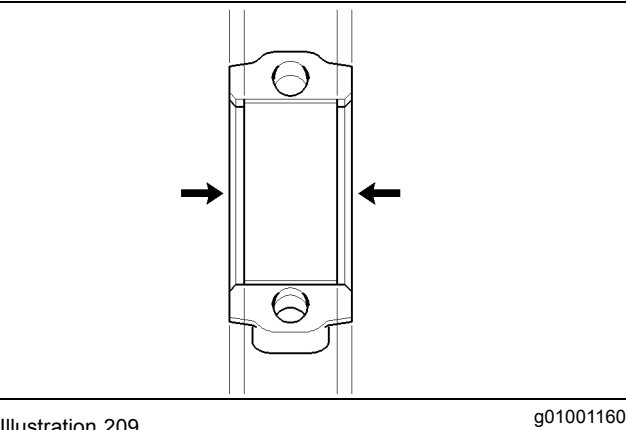
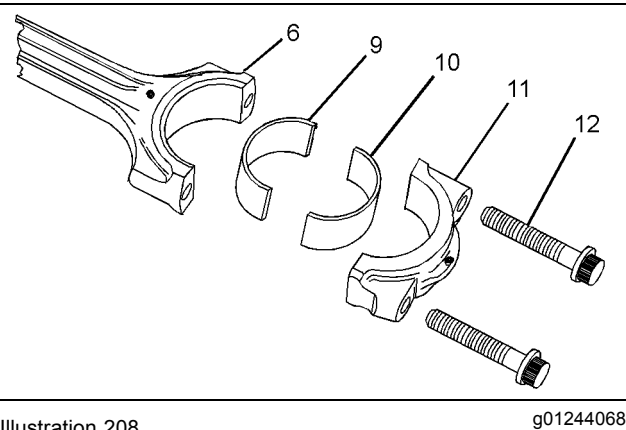
g01244172

4. Lubricate bush (8) and lubricate the bore for the piston pin in piston (4) with clean engine oil.
5. Place the piston on a suitable surface with the crown downward. Install connecting rod (6) and piston pin (7) to piston (4). Ensure that square boss (13) on the piston, and forged Mark (X) on the connecting rod are in the correct position. See illustration 207.

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of $45^{\circ} \pm 5^{\circ}\text{C}$ ($113^{\circ} \pm 9^{\circ}\text{F}$).

6. Use Tooling (A) in order to install retaining rings (5) to the piston pin bore in piston (4).

Note: Ensure that the retaining rings are seated in the grooves in the piston.



Aligning the connecting rod bearing in the center of the connecting rod

Note: New connecting rod bearings are supplied with an alignment tool. If new connecting rod bearings are installed, use the tool to align the bearing in the connecting rod.

7. Install the upper half of connecting rod bearing (9) to connecting rod (6). Ensure that the bearing is centralized in the connecting rod. Refer to Illustration 209.
8. Install the lower half of connecting rod bearing (10) to connecting rod cap (11). Ensure that the bearing is centralized in the connecting rod cap. Refer to Illustration 209.
9. Repeat Steps 2 through 8 for the remaining piston and connecting rod assemblies.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the assembly procedure for the piston and connecting rod is completed, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install".

End By:

- a. Install the pistons and the connecting rods. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install".

i02746437

Pistons and Connecting Rods - Install

Installation Procedure

Table 62

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	21825491	Piston Ring Compressor	1
C	21825607	Degree Wheel	1

- (1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used connecting rod bolts.

1. If the connecting rod caps were temporarily installed, remove the connecting rod caps. If necessary, thoroughly clean all of the components.
2. Apply clean engine oil to the cylinder bore, to the piston rings, to the outer surface of the piston and to the connecting rod bearings.

Note: Install the connecting rod bearings dry when clearance checks are performed. Refer to Disassembly and Assembly, "Bearing Clearance - Check". Apply clean engine oil to the connecting rod bearings during final assembly.

3. Use Tooling (A) to rotate the crankshaft until the crankshaft pin is at the bottom center position. Lubricate the crankshaft pin with clean engine oil.

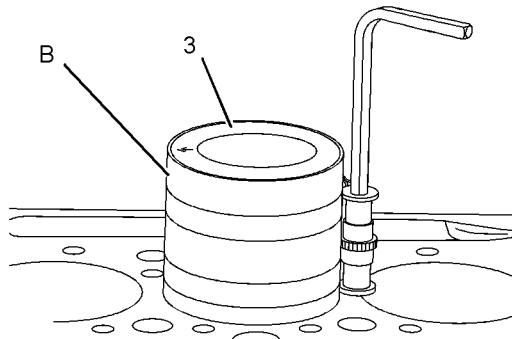


Illustration 210
Typical example

4. Ensure that the gaps for the piston rings are at 120 degrees away from each other. Install Tooling (B) onto piston (3).

Note: Ensure that Tooling (B) is installed correctly and that the piston can easily slide from the tool. Ensure that the piston and the connecting rod assembly are installed in the correct cylinder. The arrow on the top of the piston must be toward the front of the engine.

5. Carefully push the piston and the connecting rod assembly into the cylinder bore and onto the crankshaft pin.

Note: Do not damage the finished surface of the crankshaft pin.

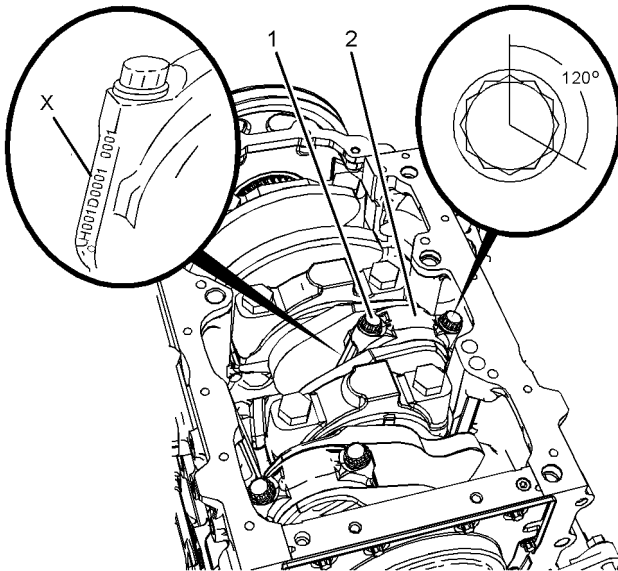


Illustration 211
Typical example

6. Install connecting rod cap (2) onto the connecting rod.

Note: Ensure that etched Number (X) on the connecting rod cap matches the etched number on the connecting rod. Ensure the correct orientation of connecting rod cap (2).

7. Install new bolts (1) to the connecting rod. Tighten the bolts evenly to a torque of 18 N·m (13 lb ft).

8. Tighten the bolts evenly to a torque of 70 N·m (52 lb ft).

9. Use Tooling (B) to turn the bolts through an additional 120 degrees.

10. Ensure that the installed connecting rod assembly has tactile side play. Carefully rotate the crankshaft in order to ensure that there is no binding.

11. Repeat Steps 2 through 10 in order to install the remaining pistons and connecting rods.

12. Check the height of the pistons above the top face of the cylinder block. Refer to Systems Operation, Testing and Adjusting, "Piston Height - Inspect" for the correct procedure.

End By:

- a. Install the piston cooling jets. Refer to Disassembly and Assembly, "Piston Cooling Jets - Remove and Install".
- b. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".
- c. Install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".

i02746439

Connecting Rod Bearings - Remove (Connecting rods in position)

Removal Procedure

Table 63

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used connecting rod bolts.

1. Use Tooling (A) to rotate the crankshaft until the crank pin is at the bottom center position.

If necessary, remove the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

Note: Removal of the glow plugs aids removal of the connecting rod bearings. It is not essential.

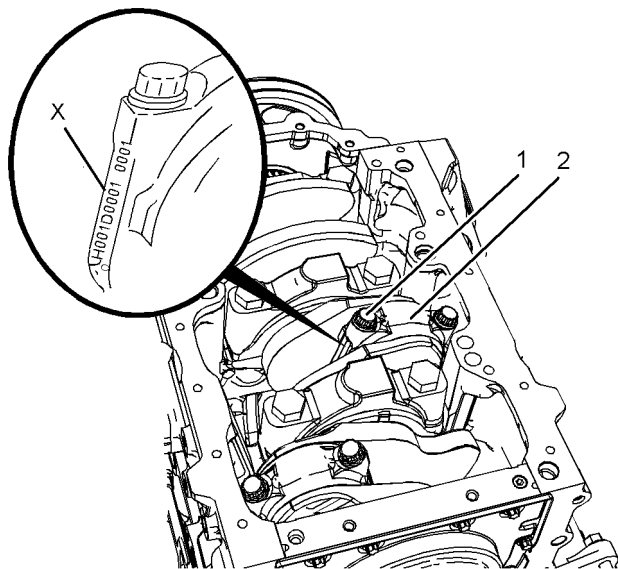


Illustration 212

g01400138

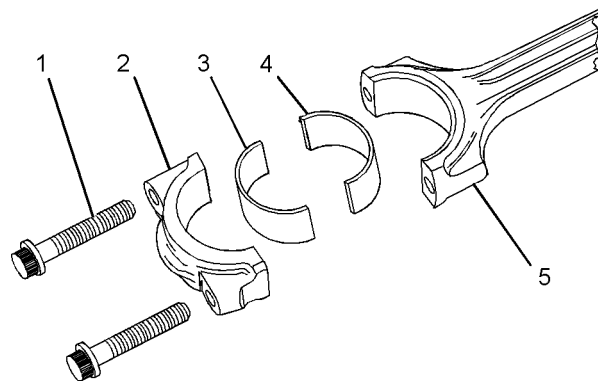


Illustration 213

g01253101

2. The connecting rod and the connecting rod cap should have an etched Number (X) on the side. The number on the connecting rod and the connecting rod cap must match. If necessary, make a temporary Mark on connecting rod (5) and connecting rod cap (2) in order to identify the cylinder number.

Note: Do not punch identification Marks onto fracture split connecting rods. Do not stamp identification Marks onto fracture split connecting rods.

3. Remove bolts (1) and connecting rod cap (2) from connecting rod (5). Discard the bolts.
4. Remove the lower half of connecting rod bearing (3) from connecting rod cap (2). Keep the connecting rod bearing and the connecting rod cap together.
5. Carefully push the piston and connecting rod assembly into the cylinder bore until connecting rod (5) is clear of the crankshaft. Remove the upper half of connecting rod bearing (4) from connecting rod (5). Keep the bearings together.

Note: Do not push on the fracture split surfaces of the connecting rod as damage may result. Do not allow the connecting rod to contact the piston cooling jet.

Fracture split connecting rods should not be left without the connecting rod caps installed. After the removal procedure for the connecting rod bearings is complete, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

i02746440

Connecting Rod Bearings - Install (Connecting rods in position)

Installation Procedure

Table 64

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	21825607	Degree Wheel	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used connecting rod bolts.

1. Inspect the pins of the crankshaft for damage. If the crankshaft is damaged, replace the crankshaft or recondition the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Remove" and Disassembly and Assembly, "Crankshaft - Install". Ensure that the connecting rod bearings are clean and free from wear or damage. If necessary, replace the connecting rod bearings.

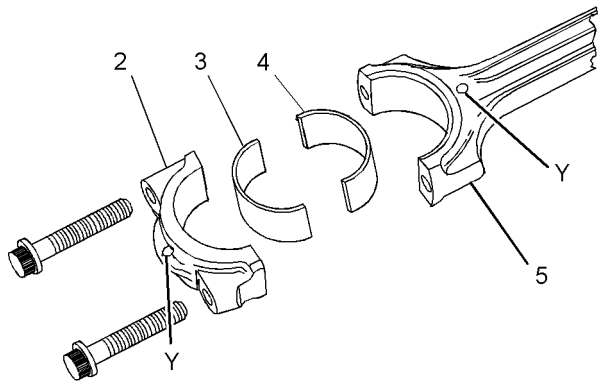


Illustration 214

g01439626

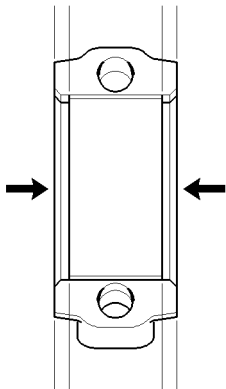


Illustration 215

g01001160

Aligning the bearing in the center of the connecting rod

Note: New connecting rod bearings are supplied with an alignment tool. If new bearings are installed, use the tool to align the bearing in the connecting rod.

2. Install the upper half of connecting rod bearing (4) to connecting rod (5). Ensure that the bearing is centralized in the connecting rod. Refer to Illustration 215.

The ends of the bearing must be centered in the connecting rod. The ends of the bearing must be equally positioned in relation to the mating faces of the connecting rod.

3. Clean the connecting rod cap. Install lower connecting rod bearing (3) to connecting rod cap (2). Ensure that the connecting rod bearing is centralized in the connecting rod cap. Refer to Illustration 215.

The ends of the lower connecting rod bearing must be centered in the connecting rod cap. The ends of the lower connecting rod bearing must be equally positioned in relation to the mating faces of the connecting rod cap.

4. Lubricate upper connecting rod bearing (4) with clean engine oil.
5. If necessary, use Tooling (A) in order to rotate the crankshaft until the crankshaft pin is at the bottom dead center position.
6. Carefully pull connecting rod (5) against the crankshaft pin.

Note: Do not allow the connecting rod to contact the piston cooling jet.

7. Lubricate the pin of the crankshaft and lubricate lower connecting rod bearing (3) with clean engine oil.

i02746443

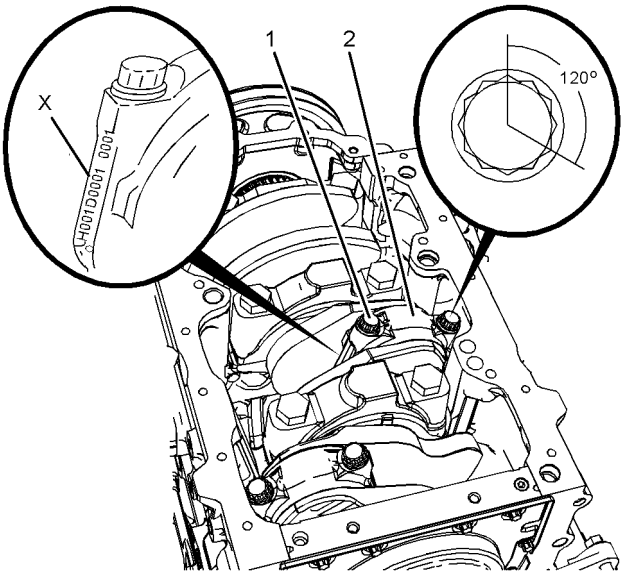


Illustration 216

g01401584

8. Install connecting rod cap (2) to connecting rod (5).

Note: Ensure that etched Number (X) on connecting rod cap (2) matches etched Number (X) on connecting rod (5). Ensure the correct orientation of the connecting rod cap. The forged Marks (Y) toward the front of the engine. Refer to Illustration 214.

9. Install new bolts (1). Tighten the bolts evenly to a torque of 18 N·m (13 lb ft).

Note: Do not reuse the old bolts in order to secure the connecting rod cap.

10. Tighten the bolts evenly to a torque of 70 N·m (52 lb ft).

11. Use Tooling (B) to turn the bolts through an additional 120 degrees.

12. Ensure that the installed connecting rod assembly has tactile side play. Carefully rotate the crankshaft in order to ensure that there is no binding.

13. Repeat Steps 2 through 12 for the remaining connecting rod bearings.

14. If the glow plugs were removed, install the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

End By:

- a. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

Crankshaft Main Bearings - Remove and Install (Crankshaft in position)

Removal Procedure

Table 65

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	21825576	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1

- (1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- b. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

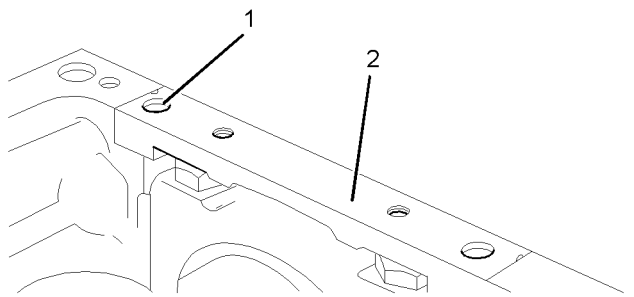


Illustration 217 g01439628

Typical example

1. Remove allen head screws (1). Remove bridge piece (2).
2. Ensure that the main bearing cap is Marked for the correct location and orientation.

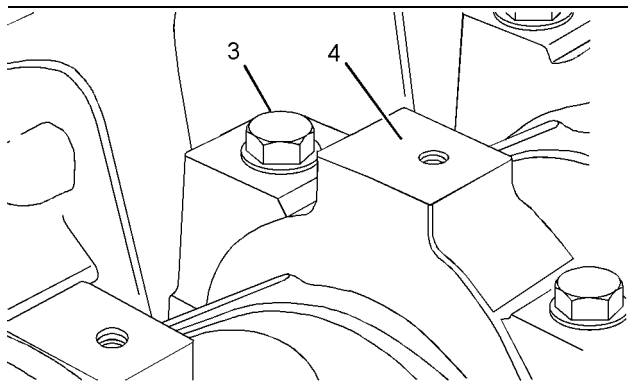


Illustration 218 g01253719

Typical example

3. Remove bolts (3). Remove main bearing cap (4) from the cylinder block.

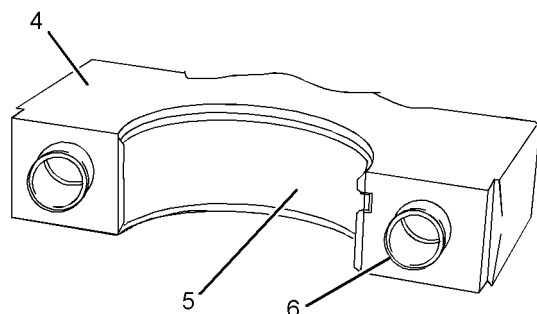


Illustration 219

g01253146

Typical example

4. Remove lower main bearing (5) from main bearing cap (4). Keep the main bearing and the main bearing cap together. Take care not to displace dowels (6).

Note: The lower main bearing is a plain bearing that has no oil holes. Dowels (6) may remain in the main bearing cap or in the cylinder block.

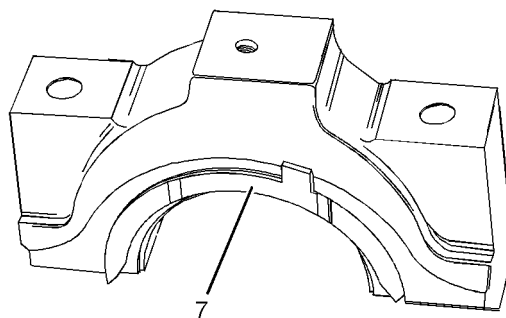


Illustration 220

g01253137

Typical example

5. For number three main bearing cap, remove thrust washers (7).

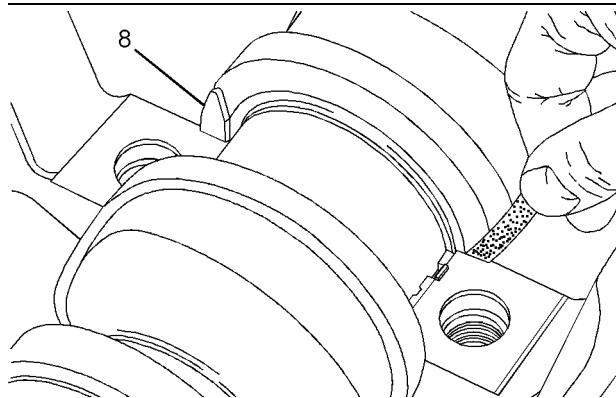


Illustration 221

g01253142

Typical example

6. For number three main bearing, remove thrust washers (8) from the cylinder block. In order to remove the thrust washers, push the crankshaft toward the front of the engine or push the crankshaft toward the rear of the engine. Use Tooling (A) in order to rotate the crankshaft. If necessary, use a suitable tool to free the thrust washers.

Note: Do not damage the machined surfaces of the crankshaft during removal of the thrust washers.

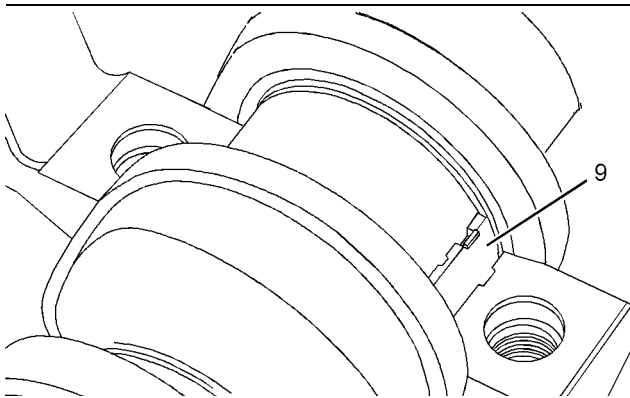


Illustration 222

g01253145

7. Push out upper main bearing (9) with a suitable tool from the side opposite the locating tab. Carefully rotate the crankshaft while you push on the bearing. Remove upper main bearing (9) from the cylinder block. Keep the bearings together.

Note: Do not damage the machined surfaces of the crankshaft during removal of the upper main bearing. The upper main bearing has a groove and two oil holes.

Installation Procedure

Table 66

Required Tools			
Tool	Part Number	Part Description	Qty
B	21825617	Dial Indicator Group	1
	-	Magnetic Base	1
C	-	Straight Edge	1
D	-	5 mm Allen Socket	1
E	21826038	POWERPART Silicon Rubber Sealant	1

NOTICE

This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the main bearings are clean and free from wear or damage. If necessary, replace the main bearings.
2. Clean the journals of the crankshaft. Inspect the journals of the crankshaft for damage. If necessary, replace the crankshaft or recondition the crankshaft.

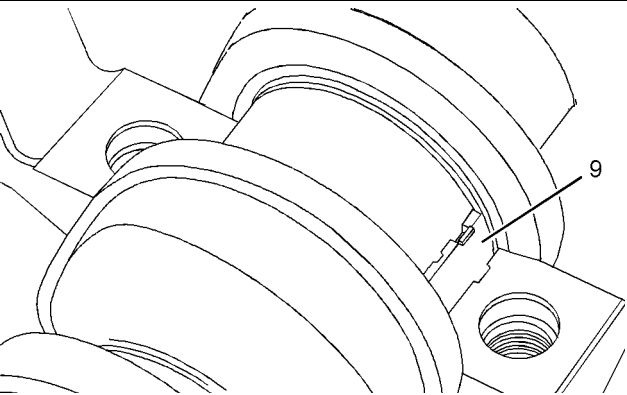


Illustration 223

g01253145

Typical example

3. Lubricate the crankshaft journal and the upper main bearing (9) with clean engine oil. Slide the upper main bearing (9) into position between the crankshaft journal and the cylinder block. Ensure that the locating tab for the upper main bearing is correctly seated in the slot in the cylinder block.

Note: The upper main bearing has a groove and two oil holes.

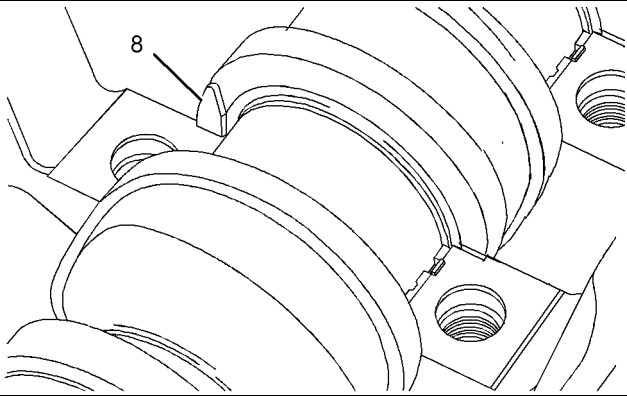


Illustration 224

g01261200

Typical example

4. For number three main bearing, ensure that thrust washers (8) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (8) with clean engine oil. Slide the thrust washers into position between the crankshaft and the cylinder block. The grooves in the thrust washers must be located against the crankshaft.

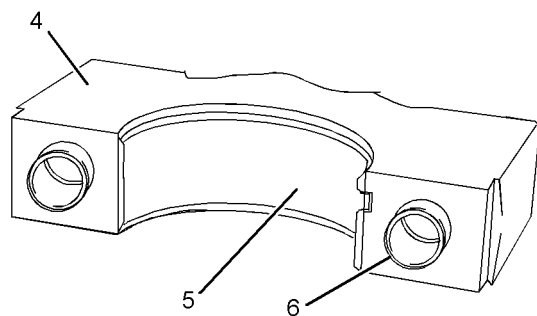


Illustration 225

g01253146

Typical example

5. Install lower main bearing (5) into main bearing cap (4). Ensure that the locating tab for the lower main bearing is correctly seated into the slot in the bearing cap.

Note: The lower main bearing is a plain bearing that has no oil holes.

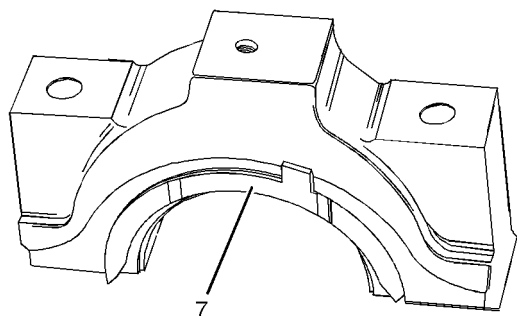


Illustration 226

g01253137

Typical example

6. For number three main bearing cap, ensure that thrust washers (7) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (7) with clean engine oil. Place the thrust washers into position on the main bearing cap. Ensure that the locating tab is correctly seated in the main bearing cap.

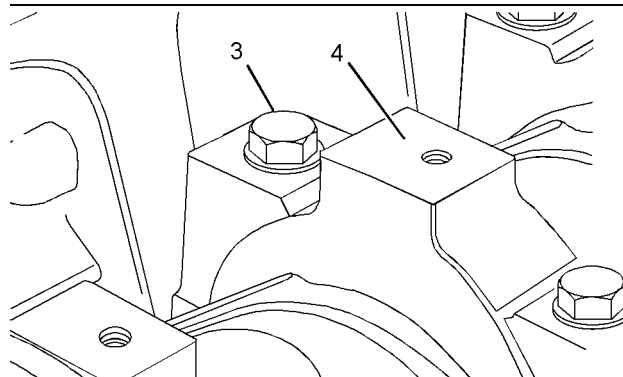


Illustration 227

g01253719

Typical example

7. Lubricate the crankshaft journal and the lower main bearing with clean engine oil. Install main bearing cap (4) to the cylinder block.

Note: Ensure the correct orientation of the main bearing cap. The locating tab for the upper and the lower bearing should be on the same side of the engine.

8. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of the bolts with clean engine oil.
9. Install bolts (3) to main bearing cap (4). Evenly tighten the bolts in order to pull cap (4) into position. Ensure that the cap is correctly seated.

Note: Do not tap the main bearing cap into position as the bearing may be dislodged.

10. Tighten bolts (3) to a torque of 245 N·m (180 lb ft).

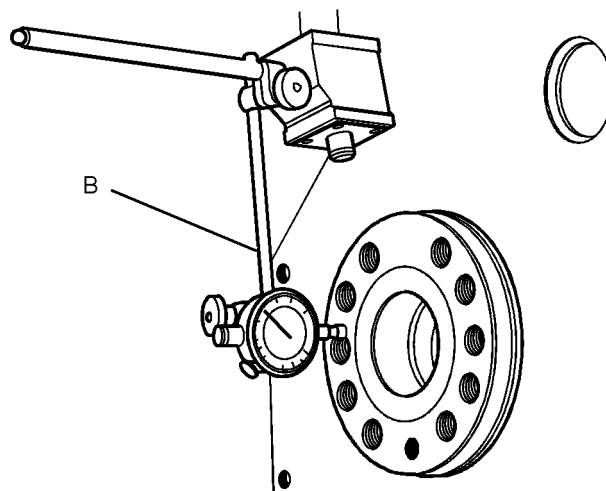


Illustration 228

g01253186

Typical example

11. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (B) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (B) to measure the crankshaft end play. The permissible crankshaft end play is 0.17 to 0.41 mm (0.007 to 0.016 inch).

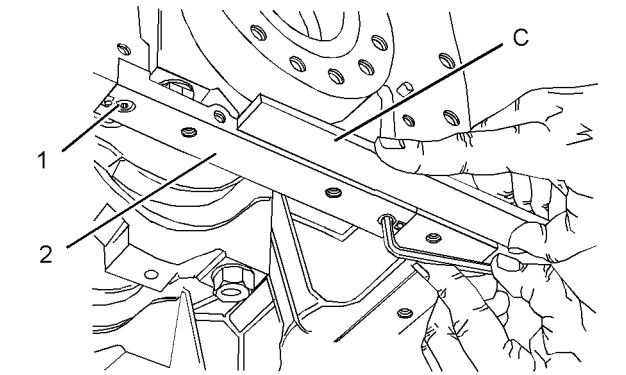


Illustration 229
Typical example

12. Follow Steps 12.a through 12.d in order to install the bridge piece.

- a. Ensure that the recess in the cylinder block and the bridge piece are clean, dry and free from old sealant.
- b. Install bridge piece (2) and allen head screws (1). Tighten the allen head screws finger tight.
- c. Use Tooling (C) in order to align the rear face of the bridge piece with the rear face of the cylinder block.
- d. Use Tooling (D) to tighten allen head screws (1) to a torque of 16 N·m (12 lb ft).

13. Install the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install".

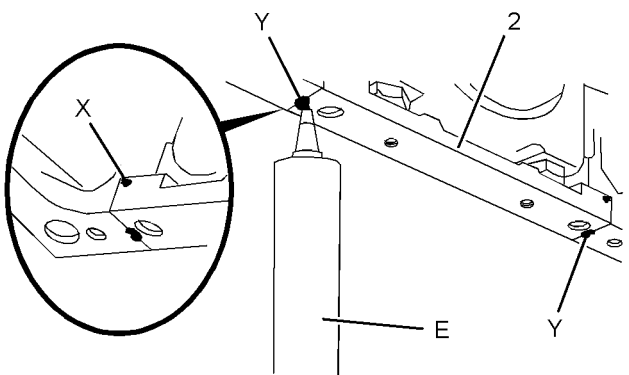


Illustration 230
Typical example

14. Apply Tooling (E) to Cavities (Y) in bridge piece (2). Continue to apply Tooling (E) until sealant extrudes from Cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece. and the cylinder block are left free of sealant.

End By:

- a. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02746445

Crankshaft - Remove

Removal Procedure

Table 67

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Lifting Strap	2

Start By:

- a. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".
- b. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".
- c. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".

- d. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

NOTICE

If the crankshaft has been reground or if the crankshaft has been replaced, the height of the piston above the cylinder block must be inspected. It is necessary to remove the cylinder head in order to inspect the height of the piston above the cylinder block.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. The engine should be mounted on a suitable stand and placed in the inverted position.
2. If necessary, remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove". Remove the pistons and connecting rods. Refer to Disassembly and Assembly, "Pistons and Connecting Rods - Remove".

If the cylinder head, the pistons and the connecting rods have not been removed, remove the connecting rod caps. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Remove".

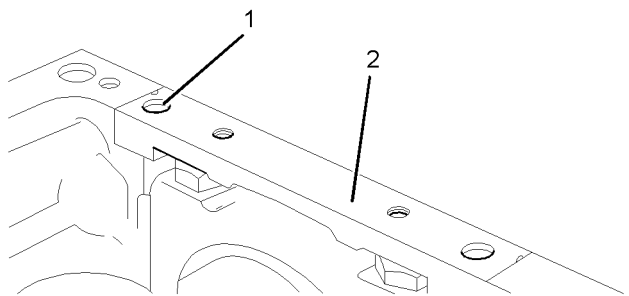


Illustration 231

g01439628

Typical example

3. Remove allen head screws (1). Remove bridge piece (2).
4. Ensure that the bearing caps are Marked for the location and orientation.

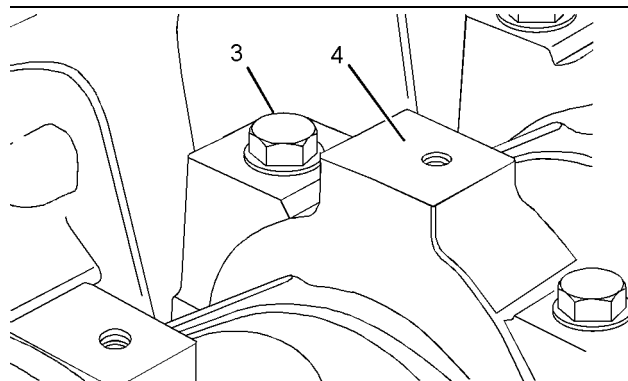


Illustration 232

g01253719

Typical example

5. Remove bolts (3) and bearing caps (4) from the cylinder block.
-

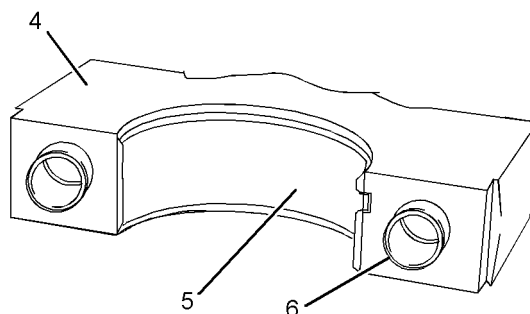


Illustration 233

g01253146

Typical example

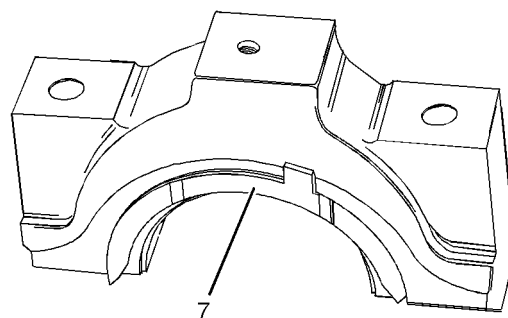


Illustration 234

g01253137

Typical example

6. Remove lower bearings (5) from bearing caps (4). Take care not to displace dowels (6). For number three bearing cap, remove thrust washers (7). Keep the lower bearing and the thrust washers with the respective bearing caps.

Note: The lower bearings are plain bearings that have no oil holes. Dowels (6) may remain in the bearing cap or in the cylinder block.

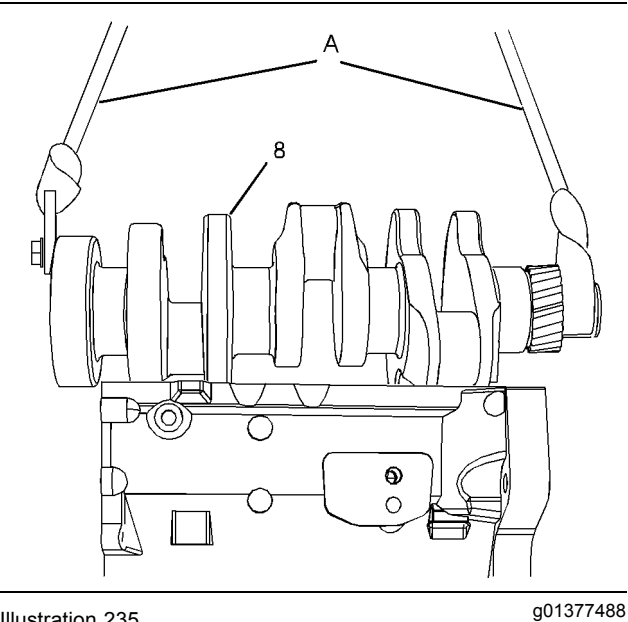


Illustration 235

g01377488

Typical example

7. Attach Tooling (A) and a suitable lifting device to crankshaft (8). Carefully lift the crankshaft out of the cylinder block. The weight of crankshaft (8) is approximately 30 kg (66 lb).

Note: It will be necessary to rotate the crankshaft in order to remove the crankshaft from the cylinder block. Do not damage any of the finished surfaces on the crankshaft, when the crankshaft is removed from the engine.

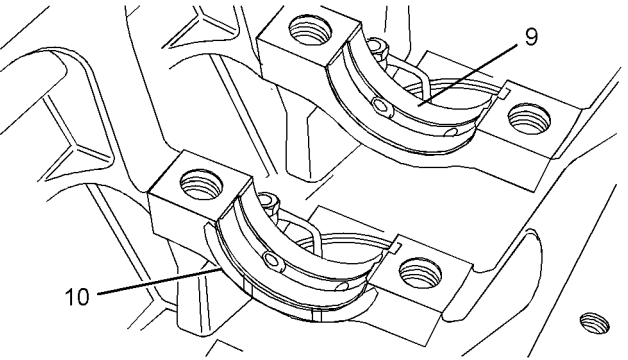


Illustration 236

g01254104

Typical example

8. Remove upper bearings (9) from the cylinder block. Keep the upper bearings with the respective bearing caps.

Note: The upper bearings have a groove and two oil holes.

9. Remove thrust washers (10) from number three bearing in the cylinder block.

10. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install".

i02746446

Crankshaft - Install

Installation Procedure

Table 68

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Lifting Sling	2
B	21825617	Dial Indicator Group	1
	-	Magnetic Base	1
C	-	Straight Edge	1
D	-	5 mm Allen Socket	1
E	21826038	POWERPART Silicon Rubber Sealant	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

If the crankshaft has been reground or if the crankshaft has been replaced, the height of the piston above the cylinder block must be inspected. It is necessary to remove the cylinder head in order to inspect the height of the piston above the cylinder block.

1. Clean the crankshaft and inspect the crankshaft for wear or damage. Refer to Specifications, "Crankshaft" for more information. If necessary, replace the crankshaft or recondition the crankshaft.

2. If necessary, install the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install".

Note: The engine should be mounted on a suitable stand and placed in the inverted position.

3. Ensure that the parent bores for the crankshaft bearings in the cylinder block are clean. Ensure that the threads for the bearing bolts in the cylinder block are clean and free from damage.
4. Clean the crankshaft bearings and the thrust washers. Inspect the bearings and the thrust washers for wear or damage. If necessary, replace the bearings and the thrust washers.

Note: If the crankshaft bearings are replaced, check whether oversize bearings were previously installed. If the thrust washers are replaced, check whether oversize thrust washers were previously installed.

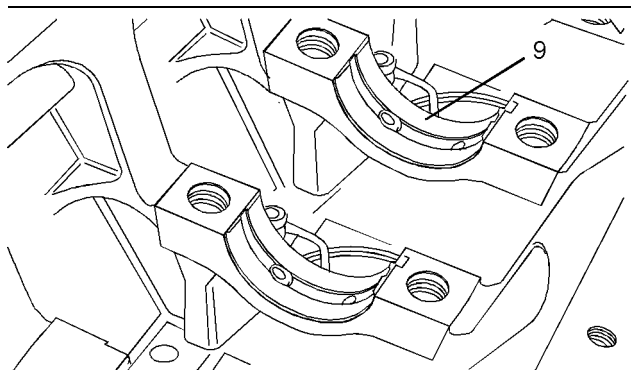


Illustration 237

g01253240

Typical example

5. Install upper bearings (9) to the cylinder block. Ensure that the locating tabs for the upper bearings are seated in the slots in the cylinder block.

Note: The upper bearings have a groove and two oil holes.

6. Lubricate upper bearings (9) with clean engine oil.

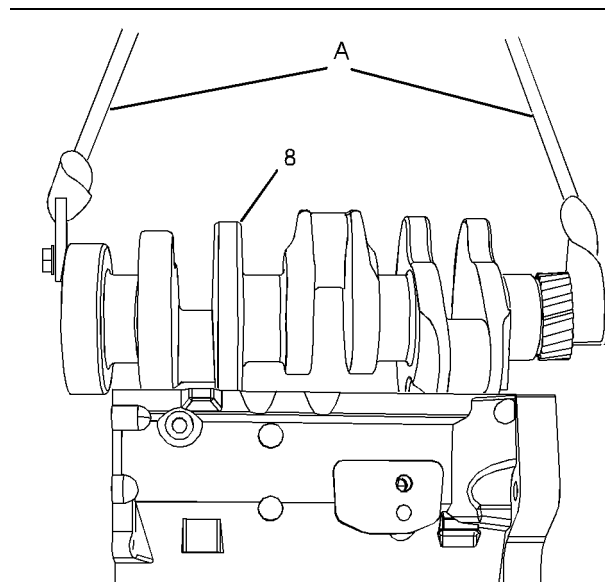


Illustration 238

g01377488

7. Attach Tooling (A) and a suitable lifting device to crankshaft (8). Carefully lift the crankshaft into the cylinder block. The weight of crankshaft (8) is approximately 30 kg (66 lb). Remove Tooling (A).

Note: It will be necessary to rotate the crankshaft in order to install the crankshaft from the cylinder block. Do not damage any of the finished surfaces on the crankshaft, when the crankshaft is removed from the engine.

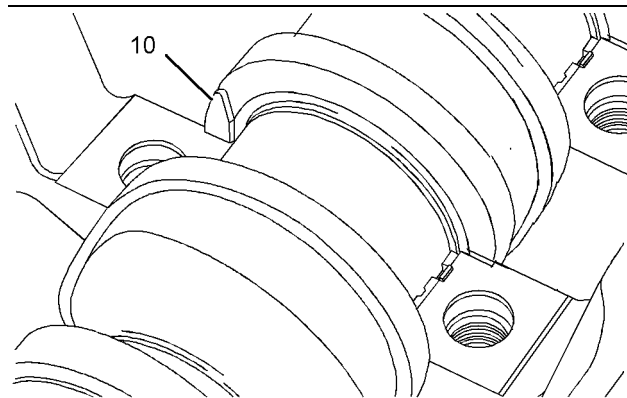


Illustration 239

g01254100

Typical example

8. For number three bearing, ensure that thrust washers (10) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (10) with clean engine oil. Slide the thrust washers into position between the crankshaft and the cylinder block.

Note: The grooves in the thrust washers must be located against the crankshaft.

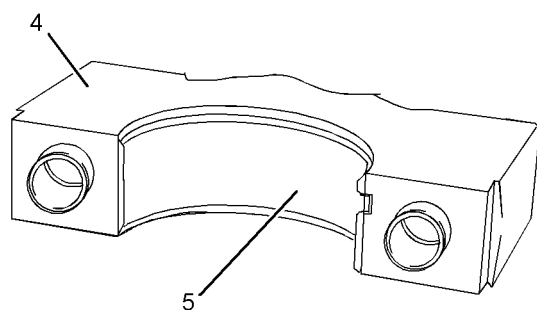


Illustration 240

g01439636

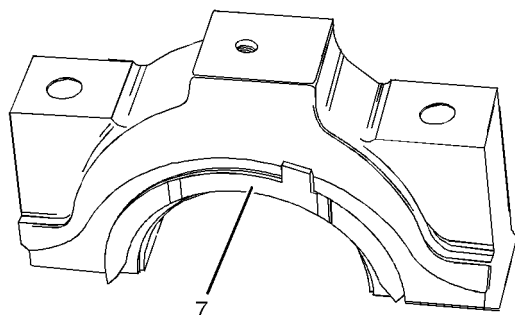


Illustration 241

g01253137

9. Install lower bearings (5) into bearing caps (4). Ensure that the locating tabs for the lower bearings are correctly seated into the slots in the bearing caps. For number three bearing cap, ensure that thrust washers (7) are clean and free from wear or damage. If necessary, replace both the thrust washers. Lubricate thrust washers (7) with clean engine oil. Place the thrust washers into position on the bearing cap. Ensure that the locating tab is correctly seated in the bearing cap.

Note: The lower bearing is a plain bearing that has no oil holes.

10. Lubricate lower bearings (5) and lubricate the journals of crankshaft (8) with clean engine oil. Install bearing caps (4) to the cylinder block.

Note: Ensure the correct location and orientation of the bearing caps. The locating tabs for the upper and the lower bearings should be on the same side of the engine.

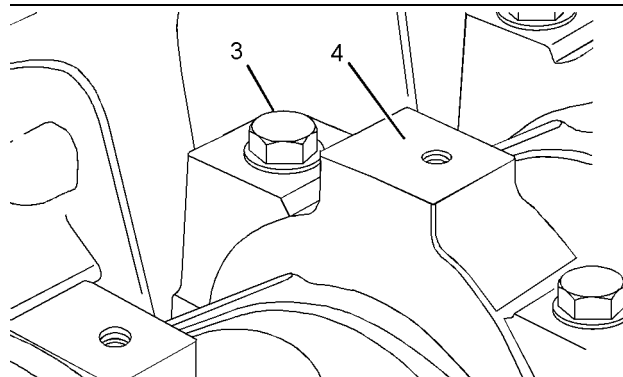


Illustration 242

g01253719

11. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of the bolts with clean engine oil.
 12. Install bolts (3) to bearing caps (4). Evenly tighten the bolts in order to pull the caps into position. Ensure that the caps are correctly seated.
- Note:** Do not tap the bearing caps into position as the bearing may be dislodged.
13. Tighten bolts (3) to a torque of 245 N·m (180 lb ft).
 14. Rotate the crankshaft in order to ensure that there is no binding.

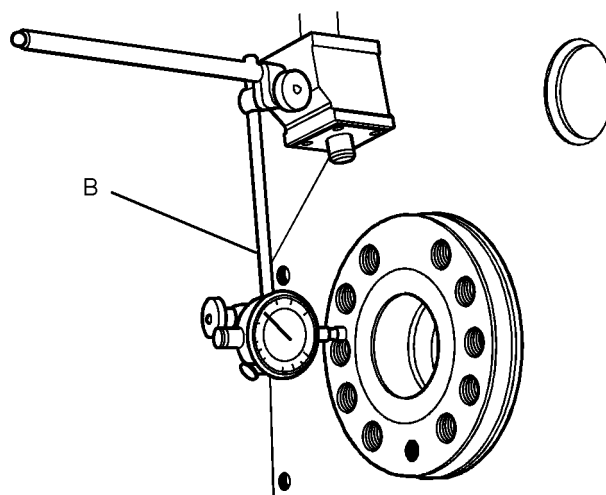


Illustration 243

g01253186

Typical example

15. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (B) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (B) to measure the crankshaft end play. The permissible crankshaft end play is to 0.17 to 0.41 mm (0.007 to 0.016 inch).

16. If the piston and connecting rods have been removed, install the piston and connecting rods. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install".

If the piston and connecting rods have not been removed, install the connecting rod caps. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

17. If the crankshaft has been replaced or the crankshaft has been reconditioned, inspect the height of the piston above the cylinder block. Refer to Systems Operation, Testing and Adjusting, "Piston Height - Inspect" for more information.

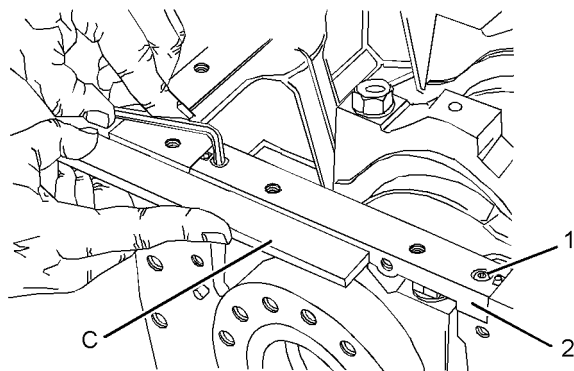


Illustration 244

g01254102

Typical example

18. Follow Steps 18.a through 18.d in order to install the bridge piece.

- a. Ensure that the cylinder block and the bridge piece are clean, dry and free from old sealant.
- b. Install bridge piece. (2) and allen head screws (1). Tighten the allen head screws finger tight.
- c. Use Tooling (C) in order to align the rear face of the bridge piece with the rear face of the cylinder block.
- d. Use Tooling (D) in order to tighten the allen head screws to a torque of 16 N·m (12 lb ft).

19. Install the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install".

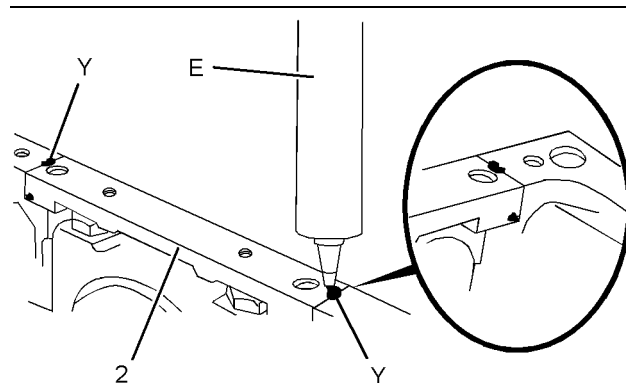


Illustration 245

g01344593

Typical example

20. Apply Tooling (E) to Cavities (Y) in the bridge piece (2). Continue to apply Tooling (E) until sealant extrudes from Cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece and the cylinder block are left free of sealant.

End By:

- a. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".
- b. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- c. If necessary, install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".
- d. Install the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rockershaft and Push Rods - Install".

i02746447

Crankshaft Gear - Remove and Install

Removal Procedure

Table 69

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Puller	1
	-	Crossblock	1
	-	Puller Leg	2

Start By:

- a. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".
- b. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The crankshaft gear may be a sliding fit on the crankshaft or an interference fit on the crankshaft.

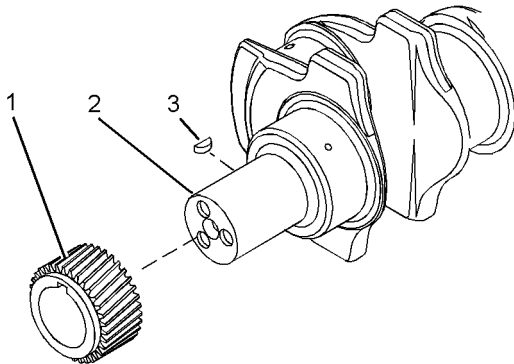


Illustration 246
Typical example

g01367358

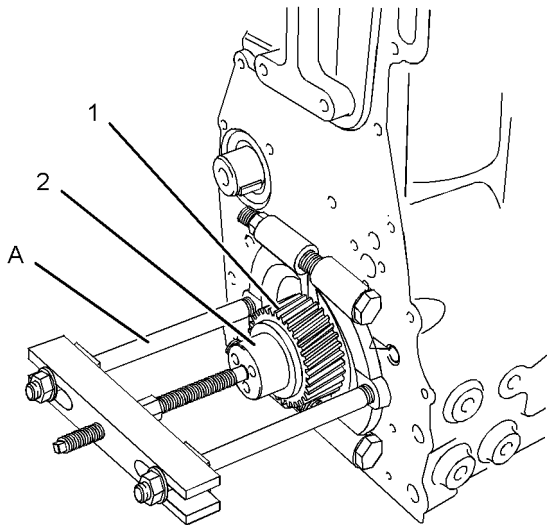


Illustration 247
Typical example

g01270549

1. If the crankshaft gear is a sliding fit on the crankshaft, remove crankshaft gear (1) from crankshaft (2).

If the crankshaft gear is an interference fit on the crankshaft, use Tooling (A) in order to remove crankshaft gear (1) from crankshaft (2).

2. If necessary, remove key (3) from crankshaft (2).

Note: Do not remove the key from the crankshaft unless the key is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.

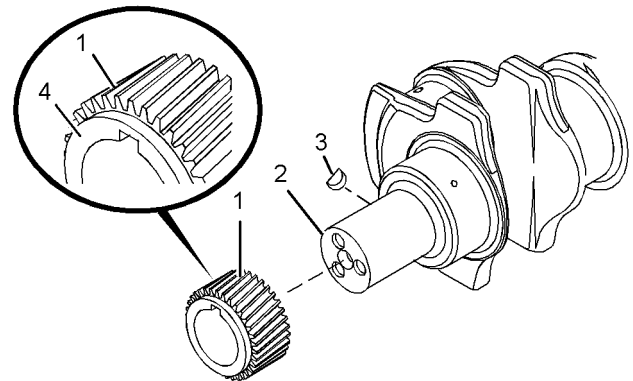


Illustration 248
Typical example

g01367359

2. If necessary, install a new key (3) to crankshaft (2).

Note: The crankshaft gear may be a sliding fit on the crankshaft or an interference fit on the crankshaft.

⚠ WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

3. If the crankshaft gear is a sliding fit on the crankshaft, align the keyway in crankshaft gear (1) with key (3) in the crankshaft. Install crankshaft gear (1) to crankshaft (2).

If the crankshaft gear is an interference fit on the crankshaft, heat crankshaft gear (1) in an oven to $150^{\circ} \pm 50^{\circ}\text{C}$ ($302^{\circ} \pm 90^{\circ}\text{F}$). Align the keyway in crankshaft gear (1) with key (3) in the crankshaft. Install crankshaft gear (1) to crankshaft (2).

Ensure that shoulder (4) on crankshaft gear (1) is toward the front of the engine.

End By:

- a. Install the front housing. Refer to Disassembly and Assembly Manual, "Housing (Front) - Install".
- b. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02748526

Bearing Clearance - Check

Measurement Procedure

Table 70

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Plastic Gauge (Green) 0.025 to 0.076 mm (0.001 to 0.003 inch)	1
	-	Plastic Gauge (Red) 0.051 to 0.152 mm (0.002 to 0.006 inch)	1
	-	Plastic Gauge (Blue) 0.102 to 0.229 mm (0.004 to 0.009 inch)	1
	-	Plastic Gauge (Yellow) 0.230 to 0.510 mm (0.009 to 0.020 inch)	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Perkins does not recommend the checking of the actual clearances of the bearing shells particularly on small engines. This is because of the possibility of obtaining inaccurate results and of damaging the bearing shell or the journal surfaces. Each Perkins bearing shell is quality checked for specific wall thickness.

Note: The measurements should be within specifications and the correct bearings should be used. If the crankshaft journals and the bores for the block and the rods were measured during disassembly, no further checks are necessary. However, if the technician still wants to measure the bearing clearances, Tooling (A) is an acceptable method. Tooling (A) is less accurate on journals with small diameters if clearances are less than 0.10 mm (0.004 inch).

NOTICE

Lead wire, shim stock or a dial bore gauge can damage the bearing surfaces.

The technician must be very careful to use Tooling (A) correctly. The following points must be remembered:

- Ensure that the backs of the bearings and the bores are clean and dry.
- Ensure that the bearing locking tabs are properly seated in the tab grooves.
- The crankshaft must be free of oil at the contact points of Tooling (A).

1. Put a piece of Tooling (A) on the crown of the bearing that is in the cap.

Note: Do not allow Tooling (A) to extend over the edge of the bearing.

2. Use the correct torque-turn specifications in order to install the bearing cap. Do not use an impact wrench. Be careful not to dislodge the bearing when the cap is installed.

Note: Do not turn the crankshaft when Tooling (A) is installed.

3. Carefully remove the cap, but do not remove Tooling (A). Measure the width of Tooling (A) while Tooling (A) is in the bearing cap or on the crankshaft journal. Refer to Illustration 249.

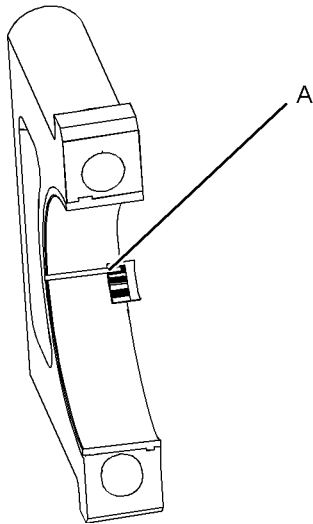


Illustration 249
Typical Example

4. Remove all of Tooling (A) before you install the bearing cap.

Note: When Tooling (A) is used, the readings can sometimes be unclear. For example, all parts of Tooling (A) are not the same width. Measure the major width in order to ensure that the parts are within the specification range. Refer to Specifications Manual, “Connecting Rod Bearing Journal” and Specifications Manual, “Main Bearing Journal” for the correct clearances.

i02746449

Glow Plugs - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Turn the battery disconnect switch to the OFF position.
2. If the engine is equipped with a cover over the fuel injectors remove the cover. Refer to Disassembly and Assembly, “Fuel Injector Cover - Remove and Install”.

3. Remove the breather tube from the valve mechanism cover. Refer to Disassembly and Assembly, “Crankcase Breather- Remove and Install”.

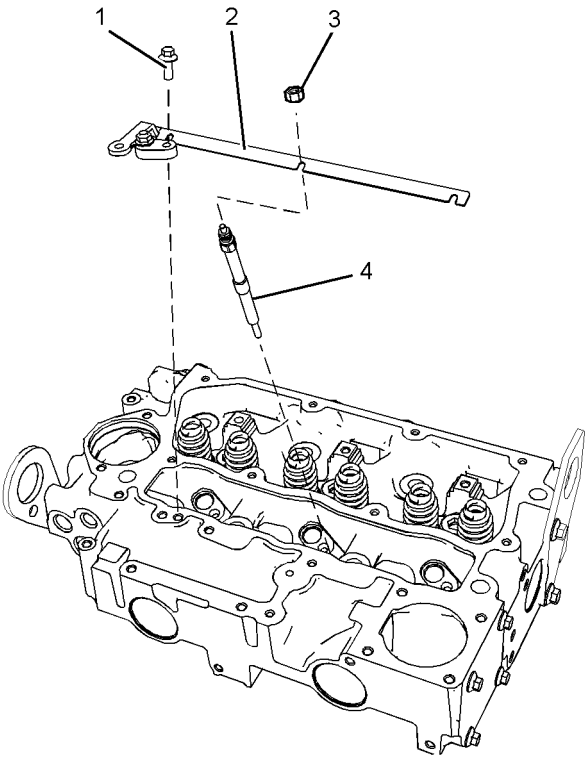


Illustration 250

4. Disconnect harness assembly from bus bar (2).
5. Remove bolt (1) that secures the bus bar (2) to the cylinder head.
6. Remove nuts (3) that secure bus bar (2) to glow plugs (4).
7. Remove bus bar (2) from glow plugs (4).
8. Remove glow plugs (4) from the cylinder head.

Installation Procedure

Table 71

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610296	Torque Wrench	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.

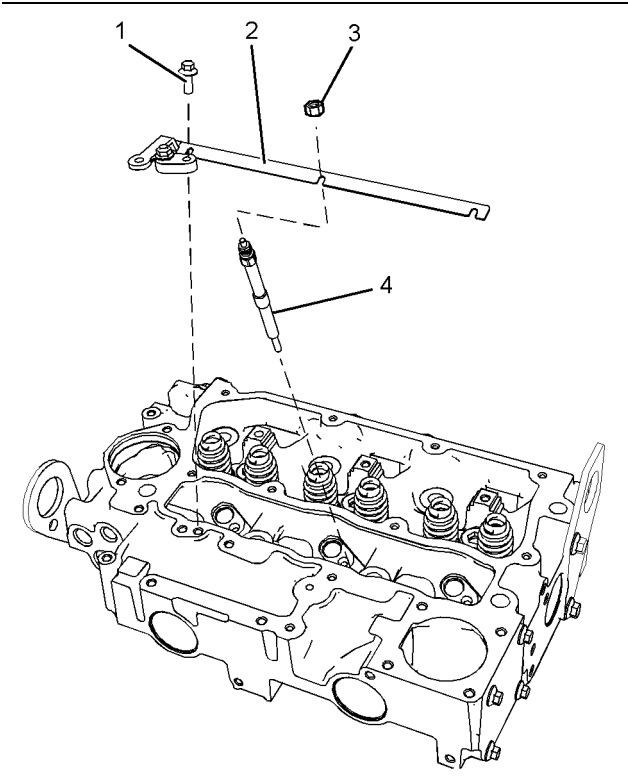


Illustration 251 g01401738

2. Install glow plugs (4) into the cylinder head. Tighten the glow plugs to a torque of 15 N·m (132 lb in).
3. Position bus bar (2) onto glow plugs (4). Install nuts (3) onto the glow plugs. Use Tooling (A) in order to tighten the nuts to a torque of 2 N·m (17 lb in).
4. Install bolt (1) and tighten the bolt to a torque of 9 N·m (80 lb in).
5. Connect harness assembly to bus bar (2).
6. Install the breather tube to the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".
7. If the engine is equipped with a cover over the fuel injectors install the cover. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
8. Turn the battery disconnect switch to the ON position.

i02746465

V-Belts - Remove and Install

Removal Procedure

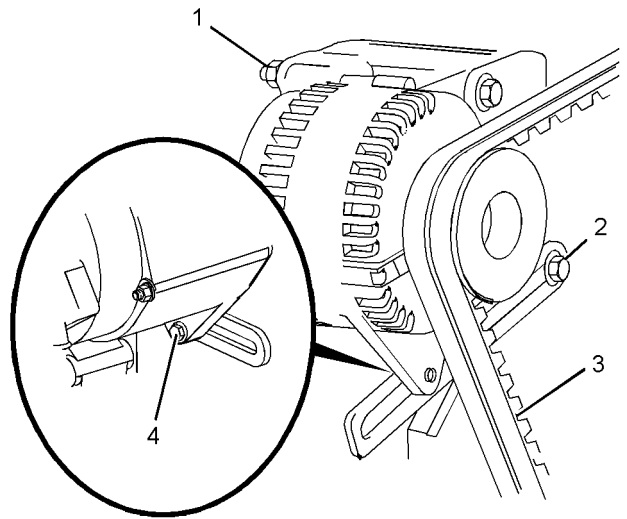


Illustration 252 g01401773
Typical example

1. If the engine is equipped with fan guards, remove the fan guards.
2. Loosen nut (1), bolt (2), and bolt (4). Slide the alternator toward the engine.
3. Remove V-belts (3).

Note: Mark the position and direction of rotation if the V-belts will be reused. Never replace single V-belts. Always replace V-belts as a pair.

Installation Procedure

Table 72

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Belt Tension Gauge	1

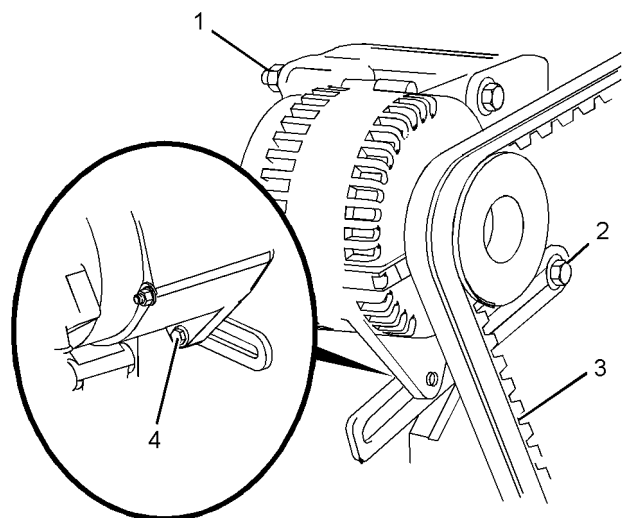


Illustration 253

g01401773

Typical example

1. Install V-belts (3) onto the correct pulleys.

Note: Used V-belts should be installed in the original position and direction of rotation.

2. Adjust the tension on the V-belts by moving the alternator away from the engine. Use Tooling (A) in order to achieve the correct belt tension. Refer to Operation and Maintenance Manual, "V-Belts - Inspect/Adjust/Replace" for more information. Tighten bolt (4) to a torque of 22 N·m (16 lb ft).
3. Tighten bolt (2) to a torque of 44 N·m (32 lb ft).
4. Tighten nut (1) to a torque of 22 N·m (16 lb ft).
5. If the engine is equipped with fan guards, install the fan guards.

i02746467

Fan - Remove and Install

Removal Procedure

Start By:

- a. Remove the V-Belts. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

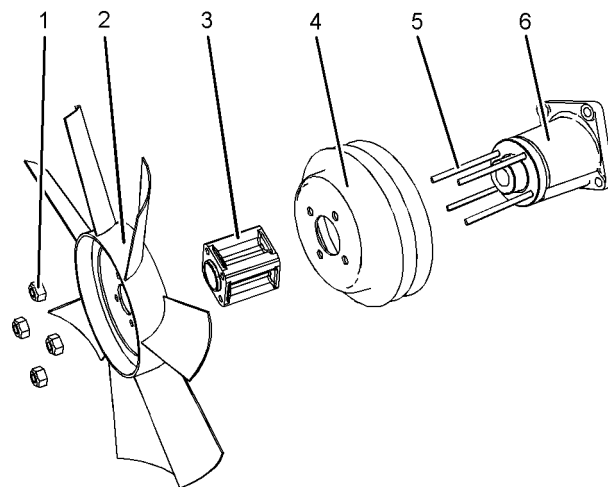


Illustration 254

g01420406

Typical example

1. Remove locking nuts (1).

2. Remove fan (2).

Note: Note the orientation of the fan.

3. Remove fan adapter (3).
4. Remove fan pulley (4).
5. If necessary, remove studs (5) from fan drive (6).

Installation Procedure

1. Ensure that all the components are free from wear or damage. If necessary, replace any components that are worn or damaged.

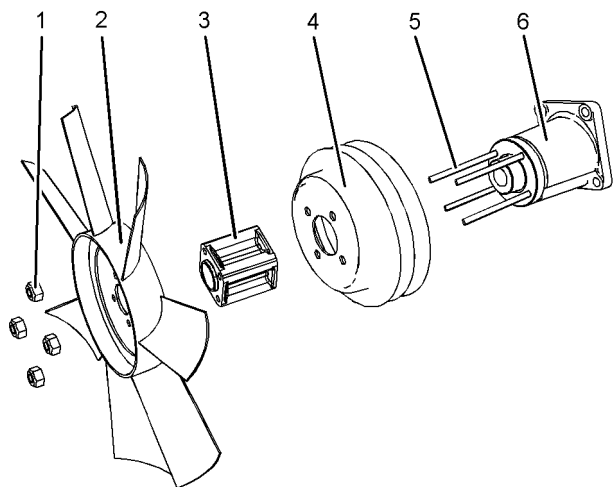


Illustration 255

g01420406

Typical example

2. If necessary, install studs (5) to fan drive (6).
3. Install fan pulley (4).
4. Install fan adapter (3).
5. Install fan (2).

Note: Ensure that the fan is correctly oriented.

6. Inspect the condition of locking nuts (1). If necessary, replace the locking nuts. Install locking nuts (1) and tighten to a torque of 22 N·m (16 lb ft).

End By:

- a. Install the V-Belts. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

i02746469

Fan Drive - Remove and Install

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

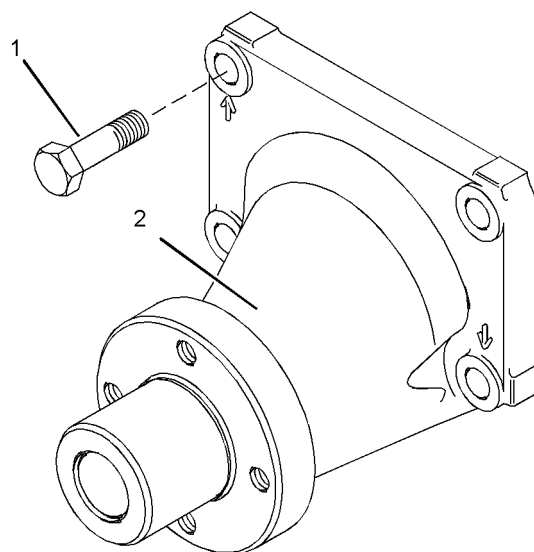


Illustration 256

g01401779

Typical example

1. Remove bolts (1) from fan drive (2).

Note: Identify the orientation and the position of the fan drive.

2. Remove fan drive (2).

Installation Procedure

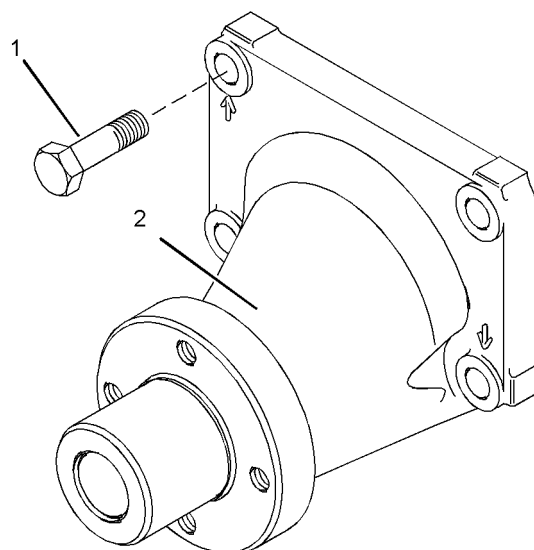


Illustration 257

g01401779

Typical example

1. Check the fan drive for wear or damage. The fan drive is not a serviceable item. If the fan drive is worn or damaged, replace the fan drive.
2. Install fan drive (2).

Note: Ensure the correct orientation of the fan drive.

3. Install bolts (1). Tighten the bolts to a torque of 44 N·m (32 lb ft).

End By:

- a. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

i02746471

Alternator - Remove

Removal Procedure

Start By:

- a. Remove the V-belts. Refer to Disassembly and Assembly, "V-belts - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Turn the battery disconnect switch to the OFF position.
 2. Make temporary identification Marks on the connections of the harness assembly.
-

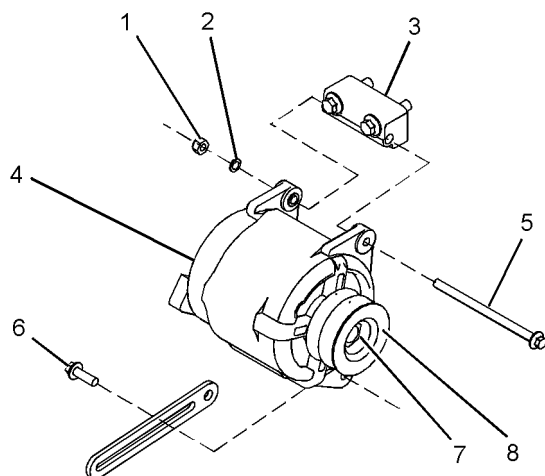


Illustration 258
Typical Example

g01255718

3. Disconnect the harness assembly from alternator (4).
4. Remove bolt (6) from alternator (4).
5. Remove nut (1) and washer (2). Remove bolt (5) from alternator (4). Remove alternator (4) from alternator bracket (3).
6. If necessary, remove pulley (8) from alternator (4). Follow Steps 6.a and 6.b for the method in order to remove the pulley from the alternator.

Note: This method may not be suitable for some configurations of pulley.

- a. Hold the shaft of alternator (4) with an allen wrench. Use a cranked ring spanner (box wrench) in order to loosen nut (7).
- b. Remove nut (7) and pulley (8) from alternator (4).

i02746472

Alternator - Install

Installation Procedure

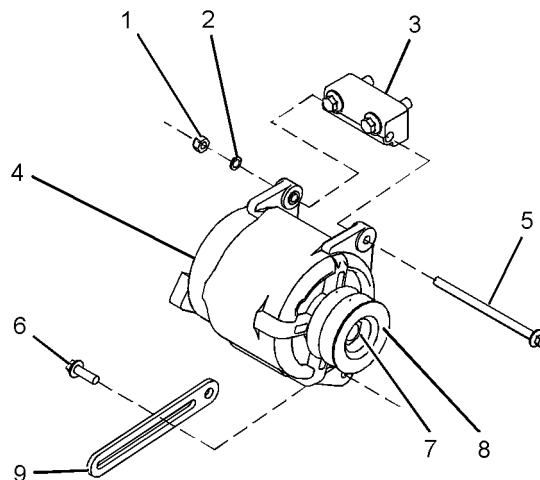


Illustration 259
Typical example

g01263045

1. If necessary, install the pulley to the alternator. Follow Steps 1.a and 1.b for the method in order to install the pulley to the alternator.

Note: This method may not be suitable for some configurations of pulley.

- a. Install pulley (8) and nut (7) to the shaft of alternator (4).
 - b. Hold the shaft of the alternator with an allen wrench. Use a cranked ring spanner (box wrench) in order to tighten nut (7). Tighten the nut to a torque of 80 N·m (59 lb ft).
2. Install alternator (4) to bracket (3) and install bolt (5) to alternator (4).
 3. Install washer (2) and nut (1) to bolt (5) finger tight.
 4. Install bolt (6) through adjusting link (9) to alternator (4) finger tight.
 5. Install the V-belts. Refer to the Disassembly and assembly, "V-belts - Remove and Install" for the correct procedure.
 6. Tighten nut (1) and bolt (6) to a torque of 22 N·m (16 lb ft).
 7. Connect the harness assembly to alternator (4).
 8. Turn the battery disconnect switch to the ON position.

i02746475

Electric Starting Motor - Remove and Install

Removal Procedure

WARNING

Accidental engine starting can cause injury or death to personnel working on the equipment.

To avoid accidental engine starting, disconnect the battery cable from the negative (-) battery terminal. Completely tape all metal surfaces of the disconnected battery cable end in order to prevent contact with other metal surfaces which could activate the engine electrical system.

Place a Do Not Operate tag at the Start/Stop switch location to inform personnel that the equipment is being worked on.

1. Turn the fuel supply to the OFF position.
2. If necessary, remove the hose for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".

3. Make temporary identification Marks on the harness assemblies that are connected to the electric starting motor and to the solenoid.

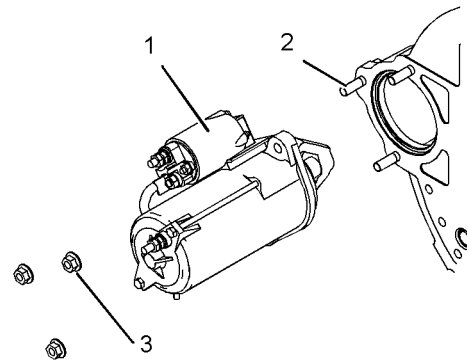


Illustration 260

g01261155

Typical example

4. Disconnect the harness assemblies from the electric starting motor and from the solenoid.
 5. Remove nuts (3) from electric starting motor (1).
- Note:** Support the weight of the electric starting motor as the nuts are removed.
6. Remove electric starting motor (1).
 7. If necessary, remove studs (2).

Installation Procedure

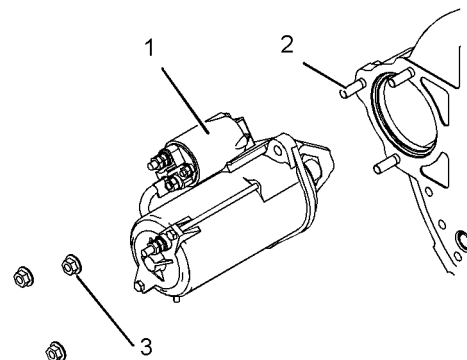


Illustration 261

g01261155

Typical example

1. If necessary, install studs (2).
2. Align electric starting motor (1) to studs (2). Install the electric starting motor.
3. Install nuts (3). Tighten nuts to a torque of 44 N·m (33 lb ft).
4. Connect the harness assemblies to the electric starting motor and the solenoid.

5. If necessary, install the hose for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Install".
6. Turn the battery disconnect switch to the ON position.

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